MAY 1951

No. 174

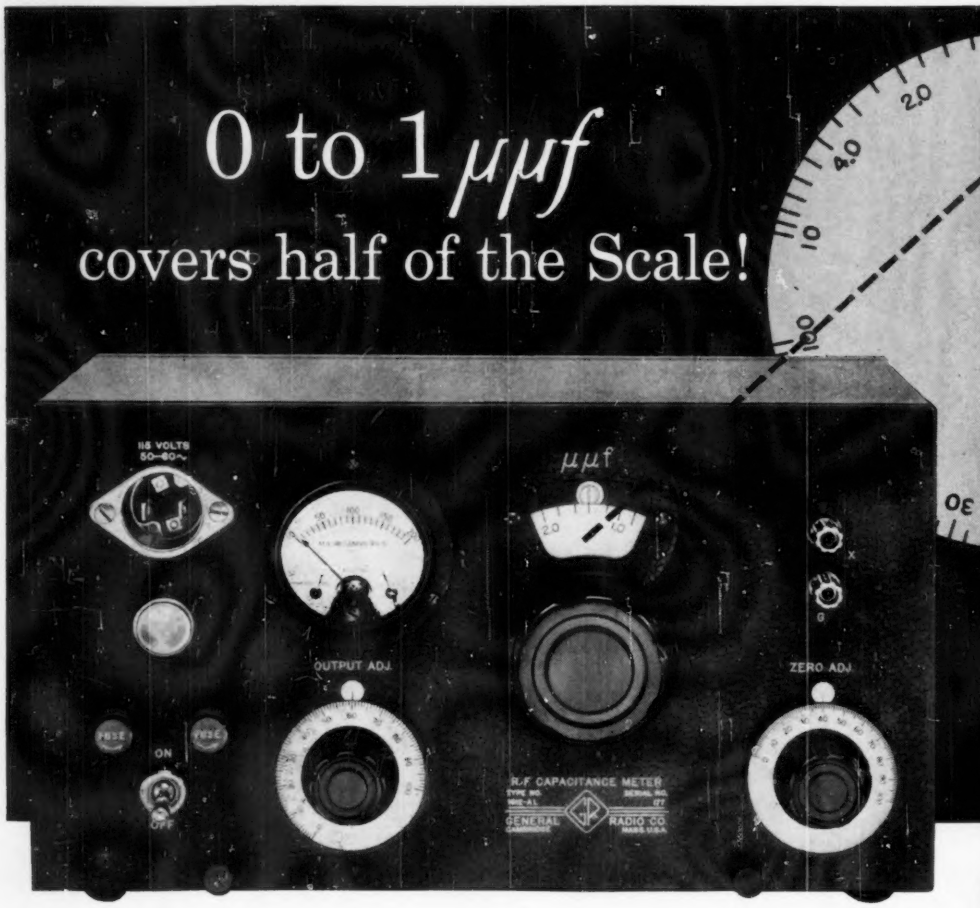
ASTM Bulletin

NEWS—News and Provisional Program for 1951 Annual Meeting; District Meetings; Technical Committee Notes.

PAPERS—Forest Products Research; Thermal Properties of Plastics; Electro Analysis of Copper; Sampling Alloys—A Bibliography; Fungus Growth on Electrical Tapes; Glass Spheres.

American Society for Testing Materials

0 to 1 $\mu\mu f$ covers half of the Scale!



The measurement of very small capacitances at radio frequencies is sometimes a difficult problem. To simplify this important measurement, G-R has developed the Type 1612-AL R-F Capacitance Meter, having two ranges from zero to 10 micromicrofarads and zero to 100 micromicrofarads.

Compact, very simple-to-use, accurate and reliable, this new meter fills a demand for many measurements of small capacitances such as:

Ceramic Capacitors — tubular ceramics (insulated and uninsulated), disc-type ceramics, tubular ceramics included in v-t sockets

Molded Mica Capacitors — foil- or silver-mica

Variable Trimmer Capacitors — variable mica, variable plate-type, variable multi-cup-type air, variable ceramic, and variable piston-type with glass dielectric

Vacuum-Tube Sockets

The operation of the instrument is very simple. Merely: (1) set the main dial to one of its two zero points, (2) turn "Zero Adjust" dial for maximum meter reading, (3) turn "Output Adjust" dial for full-scale reading on meter. Connect the unknown to the "X" terminals and retune the main dial to obtain maximum meter reading. The capacitance of the unknown is then indicated directly by the main dial setting.

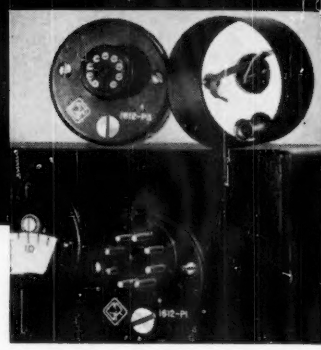
The capacitance accuracies are: LOW RANGE of 0 to 10 $\mu\mu$f: ±0.03 $\mu\mu$f below 1 $\mu\mu$f, and ±3% between 1 and 10 $\mu\mu$f; HIGH RANGE of 0 to 100 $\mu\mu$f: ±0.3 $\mu\mu$f below 10 $\mu\mu$f, and ±3% between 10 and 100 $\mu\mu$f.

On the 10 $\mu\mu$f range, the first $\mu\mu$f occupies almost one-half of the scale length, and settings can be made to 0.002 $\mu\mu$f!

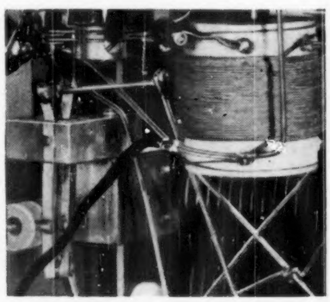
In addition, the meter can be used to approximate the dielectric loss by observing the amount by which the final tuning adjustment during measurement fails to reach full-scale on the indicating meter.

Together with its companion Type 1612-A R-F Capacitance Meter (with ranges of 0 to 1200 $\mu\mu$f and 0 to 80 $\mu\mu$f) this new meter provides an unusually simple, accurate and direct method for measuring capacitances over a very useful range, at radio frequencies.

TYPE 1612-AL R-F CAPACITANCE METER . . . $170
TYPE 1612-A R-F Capacitance Meter 170



For the measurement of r-f capacitance of tube sockets, these adaptors are required. Three are available: Type 1612-P1 for 7-pin miniature sockets, to measure "No. 4 contact to all"; Type 1612-P2 for octal sockets, to measure "No 4. contact to all"; Type 1612-P3 for 9-pin miniature noval socket, to measure "No. 5 contact to all." The adaptors fit into and shield around the "X" terminals on the meter. They are priced at $9.00 each.



In shifting from one range to another, no extra panel switching is required. The change in range is accomplished automatically as the dial is rotated from one half of the scale to the other, the switch shown above automatically performing the operation.

GENERAL RADIO Company

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MAY—1951

No. 174

KIMBLE EXAX RETESTED Cylinder No. 20030; Flask No. 28015; Burette No. 17030.

Tools of Science in the Arsenals of Democracy

THE "WIDTH" of our armed forces is measured by the fronts on which they are deployed.

The "depth" of our armed forces is measured by the miles from the front to the innermost reaches of our productive capacity.

Back of the men and machines that pour out the sinews of war in such tremendous volume stand the research laboratories. There, scientists minutely check the quality of products before they are released to those who use them in defense of democracy. There, too, scientists probe unceasingly to improve present weapons and supplies and develop new ones.

The meticulous work of thousands of scientists in these essential laboratories would dwindle, then die, without their tools—scientific instruments.

Kimble is humbly proud that the scientific instruments it produces have, in peace and war, been worthy tools in the hands of scientists everywhere.

In the turbulent times ahead, we shall do everything in our power, and ask the aid of everyone in control, to keep our nation's scientists supplied with the precision instruments we make to be weapons, as well as tools, in their hands.

KIMBLE GLASS TOLEDO 1, OHIO

Division of Owens-Illinois Glass Company

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315 | R. E. Hess, Editor | R. J. Painter, Associate Editor | CABLE ADDRESS—TESTING, Philadelphia

Number 174 | MAY, 1951

Diversified Technical Program to Feature 54th Annual Meeting

Numerous Symposiums and Technical Papers Scheduled; Many Committees to Meet

At least seven formal technical symposiums on important subjects in the field of materials are scheduled for the ASTM Fifty-Fourth Annual Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, from June 18–22, inclusive. In addition to the symposiums, there are many technical papers which are to be presented in coordinated sessions, some of these concentrated on specific topics.

Throughout the week of the meeting, it is estimated there will be over 450 meetings of technical committees. A very tentative schedule of committee meetings was sent to each member on April 12 with a precautionary note that in making hotel reservations it should be realized the schedule at this stage is tentative. Each meeting will need to be confirmed by the usual notices from the officers of the respective technical committees.

Certain features of the Annual Meeting will, as in the past, be of interest to a large number of members, including the annual address by the President, the Marburg Lecture on Corrosion Testing by F. L. LaQue, the luncheon session at which Honorary Memberships and Awards of Merit will be granted together with recognition of long-time members. Also the Board of Directors plans to invite a speaker of national importance to participate in the program. Further announcement will be made concerning this through the Circular Letter to go out late in May.

Provisional Program:

The Provisional Program in this Bulletin lists the large number of technical papers, with short abstracts or synopses, and the reports which will constitute the technical program. This information will be helpful to members in planning their stay in Atlantic City, and it is hoped that use can be made of the program by members in inviting their associates and others to attend the sessions of interest.

This particular issue of the Bulletin is being sent to all committee members in addition to the regular ASTM members, and copies of the program or of the Bulletin will be sent gladly to anyone who is interested in the technical features of the Meeting.

Entertainment Features

The Philadelphia District Council has virtually completed its plans for the annual dinner and entertainment program which it is sponsoring. The cost of the entertainment is being underwritten by members in the Philadelphia District, and the charge for this is not included in the dinner cost, thus keeping the cost of dinner tickets to a minimum. Some outstanding entertainment acts are being reserved which will be of equal interest to the ladies and the men. Dancing will follow the entertainment program.

Details for the Ladies' Program are not completed, but some of the features of previous years will be continued, and the committee in charge is considering one or two unusual events.

Personnel of Host Committees

The Philadelphia District Council acting for the District is serving as the local committee on arrangements. The officers of the Council and the men who

are in charge of the respective events are as follows:

Chairman: A. O. Schaefer, Midvale Co.
Vice-Chairman: E. J. Albert, Thwing-Albert Instrument Co.
Vice-Chairman: E. K. Spring, Henry Disston & Sons, Inc.
Secretary: Tinius Olsen, 2nd, Tinius Olsen Testing Machine Co.
Dinner: E. J. Albert
Entertainment: L. Drew Betz, W. H. & L. D. Betz
Ladies' Program: Howard S. Phelps, The Philadelphia Electric Co.
Finance: E. K. Spring

The Hostess Committee includes the wives of the members of the District Council and of Headquarters Staff members. Each member and committee member will receive late in May, as part of a special circular letter, details of the Ladies' Program, with reservation forms. The local committee is anxious to have advance information on the number of ladies who will participate in the various events, and a return form will provide a means of securing this.

Luncheon:

The luncheon scheduled for Tuesday noon and considered a session of the meeting, includes no Society business or technical papers. President Markwardt will give his address; Honorary Memberships will be awarded and several Awards of Merit are to be made, this being the second group of these awards, the first ones having been given in 1950. There is quite a group of 40-year members both company and individuals to be recognized by the presentation of certificates, but this year there are no 50-year members to be honored.

Hotel Reservations

In April there were mailed to each member and committee member a hotel reservation form together with an advance outline of the Annual Meeting sessions and committee meetings. The advance outline should help members decide when they wish to attend, and on the basis of their decision they are urged to make Hotel reservations as promptly as possible.

Committee Meetings

No advance detailed schedule of committee meetings will be distributed by Headquarters. The list of Annual Meeting sessions and committee meetings which has been attached to the Hotel reservation form should be considered as tentative only and members should await the official schedule from their respective committee officers for complete information. Final details of the schedule of the technical committees are usually not available until early in June.

Preprints of Reports and Papers

To each member a Preprint Request Blank was mailed which he should mark and return to ASTM Headquarters, indicating those papers or reports he desires. The material probably will be mailed in three installments, the final one just before or during the Annual Meeting. Furthermore, members attending the meeting can obtain, while registering, copies of preprinted papers and reports, or abstracts of items which have not been preprinted.

Technical Sessions—Papers and Reports

The opening session will feature a symposium on Bulk Sampling, which is the first formal undertaking of Task Group No. 7 on Bulk Sampling of ASTM Committee E-11 on Quality Control of Materials. The purpose of the task group, as indicated by the papers to be presented, is "to study and report on the problems of sampling materials that occur in bulk form or in packages, with the aim of estimating, at minimum cost, measureable characteristics of a quantity of material in order to get some prescribed limit of error with an assigned probability." The definition of successful bulk sampling is best described in a paper by J. Manuele on "Materials Handling for Bulk Sampling." It is necessary to preserve the identity of individual increments in the bulk lot so that each increment may be presented in the sample, either statistically or physically. Hence the problem of bulk sampling is a problem of material handling. If the bulk is made up of a large number of small increments, gathered from widely scattered sources, the problem becomes rather complicated. Therefore it is necessary that information be gathered pertinent to the particular material and to the manner in which it is normally handled, and that statistical constants be calculated accordingly.

Consolidation Testing of Soils:

This symposium is intended to bring together the various experiences in consolidation testing of soils and a knowledge of the nature of consolidation testing of soils. In a paper entitled "Aids in the Interpretation of the Consolidation Test" a short discussion of specific factors relating to testing equipment and methods that will influence the results is given. Design and construction of a small compact "Consoli-shear" machine, capable of performing both shear and consolidation tests, is described in detail. With the help of this device, testing time is reduced considerably, and actual results on shear and consolidation data proved the test to be very accurate. In consolidation testing of soils, it is important that simulated test condition be established so that results can be obtained which will apply to the actual behavior of soils under stress in a particular situation.

One paper describes laboratory tests to determine the consolidation characteristics of loess soils, index tests for estimating these characteristics, and the effect of consolidation on other soil properties.

Provisional Program

The Provisional Program outlined on page 8 is designed to give members the quickest and surest way to inform themselves of what sessions are planned and when. Short abstracts of the papers are provided and also a general statement on some of the symposiums. The official program will contain the final details of the sessions, including a complete schedule of all committee meetings, and give data on entertainment, etc. Members will receive the final program as they register.

Surface and Subsurface Reconnaissance:

Papers presented during this symposium are divided into four general groups: pedologic, geologic, airphoto, and geophysical. The procedures and methods employed in making preliminary soils-survey strip maps of proposed highways in the state of Indiana from aerial photographs are discussed. The limitations and accuracy of such aerial photo reconnaissance are considered together with an evaluation of the techniques employed. Peculiar engineering geologic problems—encountered by the Bureau of Reclamation in the construction of irrigation and other projects—due to the existence of uniformly fine-grain soils and the lack of sand, gravel, and hard durable ledge rock in the northern Plains, form the basis of another presentation. Increasing economic and military importance of the Artic region is the chief reason why information on foundation conditions in remote Artic regions should be available. This particular discussion will be confined to areas where permafrost exists, and the discussion will cover advanced studies, personnel requirements, transportation, and equipment facilities, etc.

Flame Photometry:

The opening paper of this symposium will cover and review flame photometry and its significance in material analyses. The flame photometer for the chemical analysis of biological fluids offers an exceptionally rapid method for the determination of sodium, potassium, and lithium in blood, urine, etc. Three papers are devoted to enumerate the uses of photometers in the cement and materials testing fields. Developing new test methods for the analysis of petroleum products utilizing existing flame photometry are discussed rather extensively. The application of the flame photometer in determining sodium, potassium, and other water-formed deposits in industrial waters is the basis of still another report. The flame photometer proved to give results of sufficient precision and accuracy for routine determinations without the numerous separations required in regular chemical determinations. The Perkin-Elmer and Beckman instruments are compared and a procedure is described for the determination of sodium and potassium oxides in portland cements using the Beckman flame photometer. In another paper application of the flame photometer in the analysis of lithium in portland cement is given.

Direct Pullman Accommodations to Atlantic City

Direct Pullman Service to Atlantic City will be available if a sufficient number of ASTM members from an intermediate area or route desire such service. Most railway companies will make the necessary arrangements, and those interested should contact their local ticket office.

Structural Sandwiches:

Work done at the Forest Products Laboratory on different types of paper cores for use in sandwich constructions in aircraft and houses is described. Test methods used to determine the mechanical properties of high-strength paper honeycomb core materials are analyzed and a description is given of various paper core materials for houses. Laboratory research and developments in sandwich building panels employing core materials of the rigid inorganic type—specially cellular glass and low-density calcium hydrosilicate (lime-silica)—are described. One paper will feature principally the fabrication of lightweight sandwiches for aircraft applications, such as wing coverings, floors, shear webs, and radar antenna housing.

Acoustical Materials:

This symposium will cover a number of pertinent problems connected with acoustical materials. Very few test methods exist to determine the properties of acoustical materials, especially measurements of sound absorption. The sound absorption coefficient of a material depends on its physical constants, such as flow resistivity, porosity, and thickness, on its surface condition, on the method of mounting, on the frequency of the sound, and on the angle of incidence of the sound wave. In another paper the author will discuss the "Combustibility of Acoustical Materials," pointing out the great variety of materials with their various degrees of combustibility. There is little evidence that any of the numerous methods of measurements show actual life hazards in event of a fire as far as excessive combustibility is concerned. Application of acoustical materials will be discussed in a separate paper as well as various maintenance problems. Data will be submitted which show the effect on sound absorption produced by the amount and application of different paints. "Breathing," precipitation processes, and direct impingement which are responsible for susceptibility to staining of acoustical materials will also be discussed.

Ultimate Consumer Goods—Their "Wantability":

The Administrative Committee on Ultimate Consumer Goods will present a Symposium on determination of Wantability of Consumer Goods. The papers will cover both theoretical and practical approaches to this interesting problem. The symposium is divided into two sessions, the first session featuring two reports on "Determination of Soldier Wants" and "A Survey of Food Preferences." A discussion on these two papers will close the first session. The second session will feature papers on Interviewer Bias, Panel Survey Methods, Effective Sampling Procedures, together with an introduction to the session which will explain the functions of the committee.

Of special interest to many ASTM members should be a paper presented at a special meeting of Committee D-1 on Paint, Varnish, Lacquer, and Related Products. The paper scheduled for Wednesday, June 20, at 10:30 a.m. is by R. J. Wirshing, General Motors Corp., on the subject of "Weathering of Paints." The committee is extending a cordial invitation to all those interested to attend.

New Theory on Chalking of Finishes:

In the investigation as to the cause of chalking of automotive finishing materials, a study of climatic variations and their effect on paints, was made. In one of the tests being conducted in Florida an explosion occurred. This explosion lead to the development of an entire new theory as to the causes and probable means of preventing chalking. This paper will present the work done in regard to this problem which brought about the conception of this new theory.

Other Subjects.

Some of the other topics to be covered in the regular session are:

- The Fatigue Test as Applied to Lead Cable Sheath;
- Compression Tests on Lead Alloys at Extrusion Temperatures;
- Mechanical Properties of Copper at Various Temperatures;
- Rheotropic Brittleness, General Behavior;
- Apparatus for Low-Temperature Tension Tests of Metals;
- An Arbitration Bar Izod Impact Test for Cast Iron;
- Creep-Rupture of Several Sheet Steels.

54th Annual Meeting

Atlantic City

June 18-22, 1951

This Program is Subject to Change

All time indicated is Eastern Daylight Saving Time

Provisional Program

FIFTY-FOURTH ANNUAL MEETING

of the

AMERICAN SOCIETY FOR TESTING MATERIALS

ATLANTIC CITY, N. J. **JUNE 18 TO 22, 1951**

Committee Meetings held throughout the week at Chalfonte-Haddon Hall

	MONDAY, June 18	TUESDAY, June 19	WEDNESDAY, June 20	THURSDAY, June 21	FRIDAY, June 22
Morning		*5th* Session on Non-Ferrous Metals (Reports B-1, B-5, B-8, B-9) *6th* Symposium on Flame Photometry *7th* Session on Statistical Aspects of Fatigue	Symposium on Chemical Analysis of Inorganic Solids by Mass Spectrometer. *13th* Session on Methods of Testing (Reports D-3, D-5, D-9, E-1, E-8) *14th* General Session Featuring Speaker on Current National Problems	*17th* Session on Concrete (Reports C-3, C-4, C-9, C-12, C-13) *18th* Non-Destructive Testing, Appearance, Non-Ferrous Metals, Creep, Corrosion-Resistant Alloys—(Reports A-10, B-2, B-6, B-7, E-2, E-3, E-4, E-7, E-12)	*24th* Symposium on Acoustical Materials (Report C-20) *25th* Report Session—(Reports B-3, D-6, D-7, D-10, D-12, D-13, D-14, D-15, D-17, D-21, C-7, C-15, C-19, D-2, D-11, D-19)
Afternoon	*1st* Opening Session—Symposium on Bulk Sampling (Reports Board of Directors, E-11) *2nd* Symposium on Consolidation Testing of Soils	*8th* Luncheon Session — President's Address, Award of Honorary Memberships, 40-Year Memberships, Award of Merit, Introduction of New Officers *9th* Symposium on Flame Photometry (*Continued*) *10th* Symposium on Surface and Subsurface Reconnaissance (Report D-18)	*15th* Session on Effect of Temperature on Metals (Reports A-1, A-3, A-7, Jt. Effect Temperature) *16th* Marburg Lecture — Corrosion Testing, by F. L. LaQue. Medal Awards 4 p.m.	*19th* Session on Plastics (Reports D-1, D-16, D-20) *20th* Symposium on Measurement of Consumer Wants *21st* Session on Cementitious Materials, Asphalts (Reports C-1, C-2, C-8, C-16, C-18, C-21, C-22, D-4, D-8)	
Evening	*3rd* Symposium on Bulk Sampling (*Continued*) *4th* Sessions on Fatigue and Non-Ferrous Metals (Report B-4)	*11th* Symposium on Surface and Subsurface Reconnaissance (*Continued*) *12th* Session on Fatigue (Report E-9) Paper on Weathering of Paints	Cocktail Party and Annual Dinner ENTERTAINMENT 6.30 p.m.	*22nd* Symposium on Measurement of Consumer Wants (*Continued*) *23rd* Symposium on Structural Sandwich Construction	

Monday, June 18 2 p.m. First Session

Held Simultaneously with Second Session

Opening Session

Symposium on Bulk Sampling

Formal Opening of the Fifty-fourth Annual Meeting. President L. J. Markwardt.

Approval of Minutes of 1950 Annual Meeting

Report of Board of Directors—C. L. Warwick, Executive Secretary.

Report of Committee E-11 on Quality Control of Materials. H. F. Dodge, chairman.

Symposium on Bulk Sampling

This symposium represents the first formal undertaking of the Task Group No. 7 on Bulk Sampling of the ASTM Committee E-11 on Quality Control of Materials. Established in 1948, the task group has conducted two informal meetings prior to this. In the intervening years, several members of the task group individually have made important contributions to the literature on the subject.

Materials Handling for Bulk Sampling. J. Manuele, Westinghouse Electric Corp.

The importance of the problem of sampling bulk materials is recognized. It is also recognized that any lot can be sampled, provided we know it is homogeneous. Therefore, the problem of bulk sampling is resolved into one of creating a lot which is homogeneous for the purpose of sampling. Handling methods are described which result in creating such a homogeneous lot economically. Assignable causes which may provoke changes in any lot are recognized and analyzed. In the creation of a homogeneous lot for the purpose of sampling, consideration is given to the differences between random samples and purposeful "layering," and which may be more productive of the desired results.

Economic Accumulation of Variance Data in Connection with Bulk Sampling. L. Tanner and M. Lerner, U. S. Customs Laboratory.

Estimates of two variances, between and within, must be available in order to employ the technique for establishing sampling schedules for bulk materials discussed in a previous paper by Tanner and Deming, "Some Problems in the Sampling of Bulk Materials," ASTM *Proceedings*, 1949. Frequent or continuous redetermination of these variances is necessary to establish the continued applicability of a sampling schedule. When each secondary unit is inspected individually in routine operations, continuous data are available at no extra cost. But when testing is expensive, samples are usually composited, in which case the variance data are lost. A plan is discussed whereby these data may be made available for variance estimates even though samples are composited for economy in testing.

Two-Stage Acceptance Sampling by Attributes. C. W. Dunnett, Department of National Health and Welfare, and J. W. Hopkins, National Research Council.

This paper describes a minimum-cost two-stage single sampling plan for classification of good and bad quality lots with risks of error specified by this distribution.

Bulk lots of a product, to be passed or rejected on the basis of their proportions of defective items, sometimes consist of large numbers of containers each enclosing several thousand individual items, with a high labor cost of opening a container relative to that of examining an individual item prohibiting inspection of any large number of separate containers. When nonuniformity exists between containers, the negative hypergeometric distribution may provide a probability model satisfactorily describing the sampling results obtained.

(Continued in Third Session)

Monday, June 18 2.30 p.m. Second Session

Held Simultaneously with First Session

Symposium on Consolidation Testing of Soils

The consolidation test is a fundamental strength test for soils not only for estimating the probable magnitude and time rate of settlement of foundations of structures, but also as the basic step in preconsolidating soil specimens for determining their essential shearing strength characteristics and stress-strain relations. This symposium is intended to bring together the varied experiences in consolidation testing of soils and knowledge of the nature of consolidation phenomena under varied controlling conditions in natural situations and as modified by structures and by construction methods and practices. This information is intended to be a part of a growing body of authoritative knowledge, which should serve a useful purpose as a guide and as a basis for setting up consolidation testing techniques to meet particular situations.

Report of Consolidation Tests with Peat. L. A. Palmer and J. B. Thompson, Bureau of Yards and Docks.

This paper discusses consolidation tests of peat in connection with a settlement study of two earth-filled concrete barricades. Consolidation test data with loads acting for a maximum period of 36 days are presented. The analysis of the test data and their application in estimating the magnitude and rate of future settlement are also presented. In addition, the paper contains observed settlement data of the barricades since construction and shows the comparison between the predicted and observed settlement which has occurred since the reported study was made.

Consolidation and Related Properties of Loess Soils. W. G. Holtz and H. J. Gibbs, Bureau of Reclamation.

Loess material which covers much of Nebraska, Kansas, and part of South Dakota within the Missouri River Basin is an aeolian material and is frequently very loose and susceptible to high degrees of consolidation. However, the material has high strength when dry and very low strength when wetted. This paper describes the tests to determine the consolidation characteristics for different moisture conditions and the effect of consolidation on other soil properties. Present practices of design and construction of hydraulic structures founded on loess soils are discussed.

Settlement of the Railroad Embankment Crossing of the Morganza Floodway, Louisiana. W. G. Shockley and C. I. Mansur, Waterways Experiment Station, Vicksburg, Miss.

Laboratory consolidation test procedures and settlement computations are presented for a large earth embankment on a massive clay foundation. Both total settlement and time rate of settlement are shown. Comparisons are made between the design values and actual settlements of the foundation measured over a period of several years. Theoretical time settlement curves are also fitted to the observed data.

Aids in the Interpretation of the Consolidation Test. L. H. Matlock and R. F. Dawson, University of Texas.

This paper includes a brief discussion of specific factors related to testing equipment and methods that will influence the results obtained in the consolidation test. It gives a method of evaluating testing equipment and procedures by using a very accurately reproducible, de-aired and extruded sample.

A new method of curve fitting, called the slope fitting method, is presented. This new method should be considered as a supplement to the logarithm of time fitting method and is very useful in showing the areas where the laboratory time-consolidation curves are not in agreement with the Terzaghi theory and as a result the coefficients are not valid.

A Rapid Technique of Consolidation Testing. R. H. Karol, Rutgers University.

Accepted laboratory techniques for consolidation testing generally require a week's time or more. The accuracy of the test results is often inconsistent with the long period of time spent in testing. The design and assembly of a small compact "Consolishear" machine, capable of performing both shear and consolidation tests, are presented in detail. A testing technique is proposed which will materially reduce the testing time required to gather complete shear and consolidation data. Pilot studies of the Consolishear, and the proposed testing technique were conducted to compare results with accepted methods on larger consolidometers. The results of these studies are presented.

The Effect of Temperature on the Consolidation Characteristics of Remolded Clay. F. N. Finn, University of California.

Consolidation tests on clay are normally performed in a laboratory in which the temperature may vary between 60 F and 80 F whereas the temperature in the actual clay deposit from which the sample is taken may be as low as 40 F. The paper describes an investigation to evaluate the significance of this temperature difference in estimating the rate of consolidation of the natural deposit from the results of laboratory tests. The results of laboratory consolidation tests, on a remolded clay, performed in constant temperature rooms at 40 F, 50 F, 70 F, and 80 F are presented and changes in the coefficient of consolidation due to the temperature differences are compared with those computed from the variation of the permeability of the clay with temperature.

Observed Settlements Due to Consolidation on Alluvial Clay. E. S. Barber, Bureau of Public Roads.

This paper presents settlements observed at four sites along the Potomac River near Washington, D. C., and their correlation with laboratory test results. It was found that total settlements agreed with laboratory compressibilities and that the rates of settlement were accountable to primary consolidation with one exception where appreciable secondary consolidation was indicated for a peaty clay. The rate of consolidation in clay with sand lenses was more rapid than calculated for purely vertical consolidation but much less rapid than calculated for free draining lenses.

The Application of Controlled Test Methods in Consolidation Testing. D. M. Burmister, Columbia University.

Consideration is given first to the concepts and the basic principles of controlled test methods in consolidation testing of soils, which involve essentially making the test conditions and the testing techniques fit the particular behavior characteristics of the soils and the specific conditions that control or govern the actual behavior of soils under stress in a particular situation. Thus it is possible to provide more significant and basic information on soil behavior, which is more representative of actual conditions and has a more direct application to a particular situation. Applications are made with illustrative examples for different types of soils and for different controlling conditions inherent in natural situations and imposed by the particular type of structure and by construction methods and procedures.

Monday, June 18 8 p.m. Third Session

Held Simultaneously with the Fourth Session

Symposium on Bulk Sampling (*Continued*)

Coal Sampling Problems. A. A. Orning, Carnegie Institute of Technology.

The paper presents information on the peculiarities of coal sampling and the utilization of sampling procedures. An analysis of variance is presented showing the influence of coal sizing and the distribution of ash upon variability of ash content in samples from a thoroughly mixed lot.

The influence of mining procedures and coal handling on quality trends in large lots is discussed. Storms of high ash with high variability, found in run-of-mine coal, are eliminated by mixing and rejection of high ash pieces when coal is prepared by washing.

Analysis of Variance in a Sampling Experiment. W. M. Bertholf, Colorado Fuel and Iron Corp.

This paper gives complete formulas and appropriate computational methods for determining the three components of variance in an incremental sampling experiment, taking into account the weight of the various increments in each set.

A number of examples of the use of this method in analyzing the results of previously reported experiments are given, one experiment being analyzed in considerable detail to show the method, others being reported only by summarizing the detailed computations.

The use of what might be called "intermediate cross-classifications" to demonstrate "control" and adherence to the general laws of sampling is illustrated. There is a comparison of the "internal" and "external" evidence indicating the magnitude of the sampling error of the increment of unit weight.

The Design of Coal Sampling Procedures. W. M. Bertholf, Colorado Fuel and Iron Corp. (To Be Presented by Title Only).

Monday, June 18 8 p.m. Fourth Session

Held Simultaneously with the Third Session

Fatigue and Non-Ferrous Metals

Report of Committee B-4 on Electrical Heating, Resistance, and Related Alloys. S. A. Standing, Chairman.

The Fatigue Test as Applied to Lead Cable Sheath. G. R. Gohn and W. C. Ellis, Bell Telephone Laboratories.

This paper discusses the more important factors affecting the design of laboratory test methods suitable for obtaining significant fatigue data from reversed bending tests on cantilever beam specimens of lead cable sheathing alloys. Data are presented to show the effect of cycling rate, temperature, shape of specimen, alloy additions, and aging on fatigue life. The close correlation between bending fatigue tests on strip specimens and full-size sections of cable is demonstrated. The fatigue data are analyzed in terms of (1) cycle life *versus* deflection, (2) cycle life *versus* strain, and (3) cycle life *versus* stress. Photomicrographs illustrating representative laboratory and field failures are included in the paper.

The Influence of Frequency on the Repeated Bending Life of Acid Lead. J. F. Eckel, General Electric Co.

A new type of repeated bending test for lead is described and data are given for acid lead at 110 F. It is shown that at this temperature a definite relationship exists between frequency and bending life in the strain and frequency ranges studied. Extrapolation of the data to one cycle per day results in an indicated bending life shorter than that found in service. This discrepancy and the differences between laboratory tests and service conditions are discussed.

Compression Tests on Lead Alloys at Extrusion Temperatures. G. M. Bouton and G. S. Phipps, Bell Telephone Laboratories.

Load-deflection measurements made during compression tests on lead and lead alloy cylinders at various temperatures show the effects of alloying ingredients on the force required to produce deformation. The curves also furnish clues as to changes taking place in the materials during the course of the test. The load (P) to produce definite small deformations in pure lead at various temperatures (T) is shown to follow the relationship $P = Ae^{-BT}$, where A and B are constants for the material. This is the same relationship found by others in extrusion studies. The elements added to lead were those most commonly used in the manufacture of cable sheath, namely, antimony, arsenic, bismuth, silver, tellurium, and tin. When the quantities of elements added were sufficient to produce superior mechanical properties at room temperature the force required to produce deformation at the usual extrusion temperatures was also higher.

The Influence of Cold Work and Heat Treatment on the Engineering Properties of Beryllium Copper Wire. J. T. Richards, R. K. Levan, and E. M. Smith, The Beryllium Corp.

The results of tests to determine the influence of cold drawing, straightening, solution treating, and precipitation hardening on the properties of beryllium copper wire are reported. The effects of wire diameter, grain size, preferred orientation, and prior treatment on tensile strength, elongation, proportional limit, and elastic modulus are also considered.

Fatigue Tests in Axial Compression. N. M. Newmark, R. J. Mosborg, W. H. Munse, and R. E. Elling, University of Illinois.

This paper presents the preliminary results of an investigation of the behavior of materials subjected to repeated compressive loads. Exploratory studies have been conducted on gray cast iron, 24 S-T aluminum alloy and structural steel. In general, compressive failures occurred only under high stresses. In A7 steel, for example, failures were not observed at less than five million cycles until stresses in the neighborhood of 85,000 psi or higher were applied. These results, under nearly uniformly distributed axial compressive loads, are in distinct contradiction to results obtained with notched specimens or with repeated bending tests.

Prediction of Relaxation of Metals for Creep Data. Irving Roberts, Consulting Engineer. (To Be Presented by Title Only)

In recent years, evidence has been accumulating that relaxation rates of metals can be predicted from tension creep data by means of the strain-hardening assumption. This has been accompanied by considerable controversy, and the present paper presents a theoretical discussion which should help to clarify some of the confusion which has existed in this field. Following this, a study of experimental data is given, showing that the strain-hardening assumption yields accurate results not only for copper, but also for carbon steel and for the alloy S-816.

Tuesday, June 19 9.30 a.m. Fifth Session

Held Simultaneously with the Sixth and Seventh Sessions

Non-Ferrous Metals

Report of Committee B-1 on Wires for Electrical Conductors. H. H. Stout, Jr., Chairman.

Report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought. G. H. Harnden, Chairman.

Report of Committee B-8 on Electrodeposited Metallic Coatings. C. H. Sample, Chairman.

Report of Committee B-9 on Metal Powders and Metal Powder Products. W. A. Reich, Chairman.

The Creep Characteristics of Phosphorized Copper (0.019 per cent) at 300, 400, and 500 F. A. I. Blank and H. L. Burghoff, Chase Brass and Copper Co.

Creep tests at 300, 400, and 500 F. were made on phosphorized copper of 0.019 per cent phosphorus content in three annealed and three cold drawn tempers. The creep strength of the annealed copper increases with grain size at these temperatures. The lowering of creep strength produced by increasing temperature diminishes as grain size increases. The creep strength of the drawn material at 300 F. increases with degree of working, but decreases at 400 and 500 F. as softening becomes a factor. The results are compared with those previously obtained by the authors on other types of copper.

Mechanical Properties of Copper at Various Temperatures. W. H. Munse and N. A. Weil, University of Illinois.

This paper presents the results of coupon tests conducted on three types of copper at temperatures ranging from −321 F. to +400 F. The three types of base material which have been used in these studies are electrolytic tough-pitch copper, deoxidized high-phosphorous copper, and oxygen-free high-conductivity copper. These three materials have been tested in two thicknesses ($^1/_8$ in. and $^1/_4$ in.) and in two tempers (annealed and cold-rolled 5 to 7 per cent).

Rheotropic Brittleness: General Behaviors. E. J. Ripling and W. M. Baldwin, Jr., Case Institute of Technology.

The brittle behavior of a hexagonal metal (pure zinc) at temperatures less than the transition value was found to be largely strain curable (rheotropic). This suggested that rheotropism heretofore reported only in steels, is a general property of materials that show a transition temperature. Rheotropism is not confined to the brittleness induced by low temperatures. The present report shows the low ductility of zinc at high strain rates to be rheotropic. Since the brittleness of notched steels was recently found to be rheotropic it can be assumed that the brittleness induced by any of the three known embrittling variables (temperature, strain rate, stress state) is strain sensitive.

Tuesday, June 19 9.30 a.m. Sixth Session

Held Simultaneously with the Fifth and Seventh Sessions

Symposium on Flame Photometry

The principle of flame photometry has been known for a good many years. However, the practical use of this principle has increased during the last few years as a result of the production of commercially available flame photometers. The analytical chemist has always been faced with a long, tedious method of chemical analysis for sodium, potassium, lithium, calcium, and magnesium. During the recent war years, the need for quick, accurate analyses of small amounts of sodium and potassium in blood probably accelerated the work of developing a flame photometer which could meet these specification requirements.

Realizing that the flame photometer had certain inherent limitations, members of Committee C-1 investigated the possible application of this instrument to the determination of sodium and potassium in portland cement. A method of analysis was developed, using a commercial flame photometer, which gave accuracies within the limits set up by the Methods of Chemical Analysis of Portland Cement C 114-47. A tentative method of flame photometric test for Na_2O and K_2O in portland cement was adopted by the Society at the annual meeting in June, 1949, and designated ASTM C 228 – 49 T. This tentative method has facilitated and accelerated many research programs on the effect of sodium oxide and potassium oxide on cement and concrete. However, new and improved test methods have to be devised to keep abreast of new developments.

The members of Committee C-1 on Cement and Committee D-2 on Petroleum Products and Lubricants are all aware of the importance to industry of testing methods. Accordingly, they have arranged this symposium devoted entirely to methods of analysis by flame photometry so that information on new testing methods will be available. Because the use of the flame photometer in testing methods is rather new, it was felt that all members of these committees would be interested in hearing papers devoted to the fundamentals and limitations of the flame photometer and to its specific applications in these committees' respective fields.

Flame Photometry: Review and Prospect. V. M. Meloche, University of Wisconsin.

In introducing the subject of flame photometry, this paper attempts to create a background for the papers which follow. A general review of representative contributions in this field is given. Advantages and limitations of the method are highlighted. Although the procedure is used for a wide variety of samples, the widest application of the method at present involves the determination of sodium, potassium, and calcium. Among the difficulties described, those due to unfavorable ratios between background and element radiation still seem important. Of the instrumental types described special mention is made of the latest Beckman and Weichselbaum instruments.

Design, Construction and Operation of a Stable Internal Standard Flame Photometer for Sodium, Potassium, and Lithium Analysis in Biological Fluids. C. L. Fox, Jr., Columbia University.

Flame photometry offers an exceptionally rapid method for the determination of sodium, potassium, and lithium in blood, urine, body fluids, and tissues if the requisite accuracy can be obtained under routine laboratory conditions with such complex samples. With the instrument described, analyses are very rapidly performed with an accuracy of ±1 per cent. This photometer is relatively independent of fluctuations in various experimental conditions which affect the accuracy of other instruments

Use of the Beckman and Perkin-Elmer Flame Photometers for the Determination of Alkalies in Portland Cement. J. J. Diamond, and B. L. Bean National Bureau of Standards.

A procedure is described for the determination of Na_2O and K_2O in portland cement using the original model 11300 Beckman flame photometer. The results obtained on several representative cements indicate a precision and accuracy about the same as that obtainable by gravimetric methods and by the ASTM Tentative Method C 228 – 49 T using the Perkin-Elmer flame photometer. It is suggested that the ASTM and Federal Specifications permit the use, for these determinations, of other suitable instruments in addition to the Perkin-Elmer, and that the Beckman model 11300 be among those permitted.

Applications of Flame Photometry to Materials Investigations. J. L. Gilliland, Bureau of Reclamation.

Flame photometry, one of the newer techniques of instrumental analytical chemistry, is finding increasing use in a variety of materials investigations. In this paper, applications to analytical work on irrigation water, lubricating oil, ores, metals, and silicate materials, including portland cement, are discussed. Studies on the water-soluble alkalies in hydrating cements, base exchange in pozzolans, optimum gypsum content of cements, base exchange capacity of soils, and false setting behavior of cements are described, with special reference to the use of the flame photometer in this work. The paper includes an extensive list of references.

Determination of Lithium Oxide in Portland Cement. W. J. McCoy and G. G. Christiansen, Lehigh Portland Cement Co.

The paper suggests a rapid and reasonably accurate method for the determination of Li_2O in portland cement by the flame photometer. The need for such a method is suggested by several factors; (1) the present ASTM Referee Method C 114-47 (gravimetric) for the determination of K_2O and Na_2O includes any Li_2O that might be present with the Na_2O while the ASTM Tentative Method C 228 – 49 T (Flame Photometer) does not, (2) the classical methods for determination of lithium are tedious, time-consuming, and sometimes inaccurate; (3) that in some instances lithium has been found to have an effect opposite to that of sodium on the expansion associated with the alkali-aggregate reaction in concrete

(Continued in Ninth Session)

Tuesday, June 19 9.00 a.m. Seventh Session

Held Simultaneously with Fifth and Sixth Sessions

Statistical Aspects of Fatigue

Planning and Interpretation of Fatigue Tests. A. M. Freudenthal, Columbia University.

The importance of the statistical aspect of fatigue with respect to the planning of fatigue tests and of interpretation of their results is discussed. Theoretical concepts are introduced on the basis of which the character of the scatter of fatigue data can be interpreted and a possible statistical distribution function of fatigue life at constant stress amplitudes derived. This function is compared with results of recent tests, with a view of developing more effective practical procedures of fatigue testing and of interpreting fatigue data.

On the Statistical Nature of Fatigue. F. B. Stulen, Curtiss Wright Corp.

Statistical Analysis of Fatigue Data on $4\frac{1}{2}$-in. Diameter Drill Pipe. Robert Plunkett, Hughes Tool Co.

This report deals with a statistical analysis of the experimental data and gives a method for plotting the curves of a constant which represents the fraction of the total number of specimens that fail at or below a certain number of cycles. For practical purposes a $4^1/_2$ in., 16.6 lb per ft grade D drill pipe was used.

Tuesday, June 19 12.15 p.m. Eighth Session

Luncheon Session—President's Address, Award of Honorary Memberships, Award of Merit, Recognition of 40-Year Members, Introduction of New Officers

Ladies are cordially invited

Tuesday, June 19 2.30. Ninth Session

Held Simultaneously with the Tenth Session

Symposium on Flame Photometry (*Continued*)

Control of Interferences Caused by Acids and Salts in the Flame Photometric Determination of Sodium and Potassium. Frank T. Eggertsen, Garrard Wyld, and Louis Lykken, Shell Development Co.

In the flame photometric determination of sodium and potassium, substantial negative errors are produced by moderate concentrations of common acids and salts, when the instrument operates on a mist produced in a spray chamber and an internal standard is not used. These errors appear to be due principally to differences in the amount of evaporation from the mist droplets which occurs in the spray chamber. Interference from this source can be virtually eliminated by adding a high concentration of a salt or acid, as a buffer, to both the test solution and comparison standards.

The Effect of Organic Solvents on the Flame Photometric Emission of Certain Elements. G. W. Curtis, H. E. Knauer, and L. E. Hunter, Socony-Vacuum Oil Co.

Experience with a limited number of hydrocarbons used as solvents in flame photometric procedures with metallo-organic compounds suggested the possibility that other nonaqueous materials may exert an influence upon the emission characteristics of metals. In order to explore this possibility, a variety of compounds including hydrocarbons, oxygen-, nitrogen-, and halogen-containing materials were tested using both alkali and alkaline-earth metals in the form of metallo-organic compounds. The data obtained from the various combinations are presented and discussed.

Determination of Tetraethyllead in Gasoline by Flame Photometry. P. T. Gilbert, Jr., Beckman Instruments Inc.

A very rapid method of determining lead in gasoline is provided by the new flame photometry attachment for the Beckman quartz spectrophotometer. At 405.8 mμ in the oxyhydrogen or oxyacetylene flame, comparisons accurate to 0.01 ml of tetraethyllead per gallon can be made between gasolines of the same base stock. Routine determinations can be carried out at the rate of 30 or more samples per hour. It is shown that it should be possible with suitable burners to compare gasolines of different base stocks, by employing the ratio of lead emission to spectral background or to fluidity.

Determination of Calcium in Lubricating Oil by Flame Spectrophotometer. M. L. Moberg, V. B. Waithman, W. H. Ellis, and H. D. DeBois, California Research Corp.

A rapid method for determining the calcium content of oil has been devised using the flame spectrophotometer. A Beckman instrument was used for this work. The sample is dissolved in benzene and the resulting solution atomized into the flame, the intensity at 6260 angstrom wave length measured, and the intensity compared with that given by a pair of standards. At concentrations of 2 per cent or less sample in benzene, variations of viscosity of the sample have negligible effect on the accuracy. The presence of phosphorus not combined with the calcium will give no interference. Phosphorus chemically combined with the calcium will cause low results. The presence of sodium, sulfur, zinc, and lead has no effect.

A Modified Recording Flame Photometer. W. H. King and W. M. Priestley, Esso Laboratories.

A Beckman flame photometer has been modified for use as a recording instrument and has been in service for over a year in this laboratory. The use of a recording technique has proved to be advantageous in flame photometer work since zero drift, sensitivity drift, and aspirator change difficulties are compensated by a recording technique. The flame spectrum of a sample may be scanned in a few minutes, thereby presenting a rapid qualitative analysis. Unexpected elements have shown up in recorded flame spectra which otherwise may have been overlooked.

The instrument described here uses a photomultiplier detector which permits operation at extremely low light intensity levels. Through this sensitive detector system the minimum detectable amounts of many elements have been lowered.

The Flame Photometer in the Analysis of Water and Water-Formed Deposits. R. K. Scott, V. M. Marcy, and J. J. Hronas, Hall Laboratories Inc.

The use of the flame photometer in the determination of sodium and potassium in industrial water and water-formed deposits is discussed. The flame photometer is shown to give results of sufficient precision and accuracy for routine determinations without the numerous separations required in classical chemical analysis.

Raw waters, treated waters, and boiler waters are run without preliminary treatment. Deposits require only solution of the sample, the procedure for which is presented.

Since a single flame photometer determination is a matter of 10 to 15 sec, it becomes entirely practical to determine approximately the sodium or potassium content of the sample, run standard samples to bracket the estimated concentration, and interpolate linearly for the final value. A complete determination, including calculations, can thus be done in a matter of a few minutes.

Late in May each member and committee member will receive a reservation form for the Annual Dinner. It should be returned promptly.

Tuesday, June 19 2.30 p.m. Tenth Session

Held Simultaneously with the Ninth Session

Symposium on Surface and Subsurface Reconnaissance

Report of Committee D-18 on Soils for Engineering Purposes. E. J. Kilcawley, Chairman.

Symposium on Surface and Subsurface Reconnaissance

The purpose of this Symposium on Surface and Subsurface Reconnaissance is to assemble information on techniques that have been applied to this type of reconnaissance in widely varying scientific fields, and examine these techniques for their limitations as well as applications. Papers are divided into the four general groups: pedologic, geologic, air photo, and geophysical, in accordance with the procedures used for making the reconnaissance. Some describe applications of two or more methods in combination.

Oral presentation will consist of abbreviated formal descriptions followed by an informal panel discussion with the authors serving as panel members. This will be supplemented by a display of equipment and materials used in carrying out the different methods of reconnaissance.

Interpreting Geologic Maps for Engineers. E. B. Eckel, U. S. Geological Survey.

Geologic maps contain a wealth of basic information on foundations, construction materials, surface and underground water conditions, and other factors that must be considered by engineers in the planning and design of structures. Some of this information is immediately apparent from study of the map itself; much of it, however, depends on interpretations of the basic data by a geologist or by the engineer. Such interpretations are an integral part of detailed geologic investigations of specific engineering sites, but they have not been generally drawn from smaller-scale maps of larger areas. Several examples of such small-scale maps are presented and some of the many possible engineering interpretations are drawn from them.

Engineering Implications of Geological Reconnaissance in the Plains Area-Missouri River Basin. E. A. Abdun-Nur and J. D. Dowling, Bureau of Reclamation.

The prevalence of uniformly fine-grain soils and the lack of sand, gravel, and hard durable ledge rock in the northern Plains area have presented peculiar engineering geologic problems to the Bureau of Reclamation in the construction of irrigation and multi-purpose projects.

The value of geological reconnaissance and the interdependency of engineering and geology is apparent in the problems brought about by these factors and their implications in terms of engineering solutions.

Preliminary Foundation Exploration in Arctic Regions. L. A. Nees, Wright Patterson Field, and A. M. Johnson, Wayne University.

The increasing economic and military importance of the American arctic regions makes them of ever-increasing concern to the engineering profession and exploration of the unique foundation conditions becomes of paramount importance. This paper discusses some of the problems posed in making foundation explorations in remote arctic regions and outlines some methods for their solution. The discussion is largely confined to regions where permafrost predominates and covers advance studies, personnel, transportation, equipment, seasons of operation, exploration methods, and typical conditions.

Preparation of County Engineering Soil Maps for Illinois. T. H. Thornburn, University of Illinois.

It has been the aim of a cooperative research project activated in 1949 to prepare an engineering soils manual which would be useful to Illinois state and county highway engineers and yet involve a small expenditure of time and money.

The first phase of this project has been the preparation of county engineering soil maps which are based primarily on information contained in geologic literature and county agricultural reports. The accomplishment of this objective has involved the formulation of a new classification system for the correlation of pedologic information with engineering characteristics.

The Engineer Looks at Pedology. R. L. Greenman, Michigan State Highway Department.

The methods now used by soil engineers in securing the necessary information pertaining to foundations, subgrades, subbases, and construction materials are many and varied. This is especially true on highway and airport construction. By combining the outstanding features of the various methods soil surveys can be produced which will furnish the engineer with a maximum amount of information at a minimum cost. The subject paper discusses the effective application of such a combination.

Application of Aerial Photographs to Preliminary Engineering Soil Surveys. R. D. Miles, Purdue University.

The procedures and methods employed in making preliminary soils-survey strip maps of proposed highways in the State of Indiana from aerial photographs are discussed. Unrectified air photos of a scale of approximately three inches to the mile are studied with the aid of a pocket stereoscope, and soil borders drawn are traced directly to a planimetric map, at the same scale as the photographs. A photo mosaic strip map is also discussed. The classification used in conjunction with the maps is based on topography, parent material, and texture. A drainage strip map with watersheds outlined is presented.

The Preparation of an Engineering Soil Map of New Jersey. D. R. Lueder, Cornell University.

This paper discusses the use of air photos, not as a reconnaissance aid, but as a major tool in the preparation of an engineering soil map. The discussion is based upon experience gained during the preparation of an Engineering Soil Map of New Jersey, a task undertaken by the Joint Highway Research Project at Rutgers University. Since the mapping program was established, a detailed map covering an aggregate area of approximately 2000 square miles has been completed, while additional areas totaling some 1800 square miles are in various advanced stages of completion.

A Critical Review of Air Photo Analysis. D. J. Belcher, Cornell University.

This paper will consist of an evaluation of techniques and an appraisal, by land form units, of the limitations and accuracy of air photo reconnaissance. The stated objectives of the symposium will form the basis of the paper.

(Continued in the Eleventh Session)

Tuesday, June 19 8 p.m. Eleventh Session

Held Simultaneously with the Twelfth Session

Symposium on Surface and Subsurface Reconnaissance (*Continued*)

Earth Resistivity Tests Applied to Subsurface Reconnaissance Surveys. R. W. Moore, Bureau of Public Roads.

Use of geophysical methods for exploring the subsurface at proposed structure sites is expanding. In this paper the earth resistivity test is described and the theory and procedure for making tests in the field are discussed briefly. Several practical examples are described in which earth resistivity tests were used in studies of subsurface problems typical of those met with in highway construction work. The data presented are representative of a large quantity of such data obtained in the field work of the Bureau of Public Roads. The conclusion is drawn that the earth resistivity test constitutes a valuable tool for use in rapid reconnaissance surveys made prior to any more detailed subsurface survey by test pit or core drill.

Electrical Resistivity Method as Applied to Engineering Problems. H. L. Scharon, Washington University.

The theory, field practice, and interpretation of the electrical resistivity geophysical method as applied to shallow subsurface investigations are briefly discussed. The limitations and the accuracy of the method under various conditions are stressed. Practical applications of the electrical resistivity method to specific engineering problems involving modern highway construction, foundation problems, and subsurface water supplies are presented.

Geophysical Measurements of the Depth of Weathered Mantle Rock. D. Wantland, U. S. Bureau of Reclamation.

Geophysical field studies are described which were made to ascertain the depth of weathered overburden mantle rock at the proposed site of a dam, on the American River in California. The application of the electrical resistivity, the seismic refraction, and the magnetic method in attacking this problem is discussed. The interpretation procedures employed are explained. Examples of results are presented which show that the geophysical and core drill determination of the depth to sound rock agreed within less than 4 ft.

The Practical Value of an Earth Resistivity Method in Making Subsurface Explorations. W. F. Abercrombie, State Highway Department of Georgia.

This paper proposes to demonstrate the practical value of an electrical resistivity apparatus in making subsurface explorations from a highway builder's point of view. A short description of the geological formation, diagram showing the resistance curves, and description of the soil and/or rock encountered on actual excavation are given for ten

points of exploration selected from widely divergent geological formations. Results of the tests described demonstrate the versatility of the earth resistivity method of making subsurface exploration and show it to be a practical aid to evaluating underground conditions with relation to structure foundations and solid rock excavation.

Applications of Seismic Methods to Foundation Exploration. A. M. Johnson, Wayne University, and R. H. Wesley, Stickel & Co., Inc.

One phase of engineering work which has too often been slighted has been that of foundation exploration previous to design and construction. It is felt that seismic work has proved itself in highway and foundation work and is frequently necessary in conjunction with soils mechanics for a thorough understanding of foundation conditions. This paper explains the theory and techniques of seismic investigations and describes the applications to several foundation problems.

Seismology Applied to Shallow Zone Research. D. Linehan, Boston College.

Although seismology has been employed for some time in both shallow and deep surveys, with the theory and method described in books and journals, this paper concentrates the results of several years of field work and computation of refraction records performed by the author to demonstrate the techniques and dodges found most useful by him and his associates.

The paper includes work on highway research, ground water supplies, building foundations, location of materials, drainage problems, damsite studies, and other problems where a knowledge of the proximate subsurface geology is an important factor to the engineer.

Resistivity Reconnaissance. I. Roman, U. S. Geological Survey.

Tuesday, June 19 8 p.m. Twelfth Session

Held Simultaneously with the Eleventh Session

Fatigue

Report of Committee E-9 on Fatigue. R. E. Peterson, Chairman.

Fatigue Strength of Ball Bearing Races and Simple Test Specimens of 52100 Steel Heat Treated to High Hardness. Haakan Styri, SKF Industries Inc.

Endurance tests have been run on ring type, Krouse type, rotating beam type, and torsion type specimens made of ball bearing steels and heat treated in various ways to high hardness. The relation of median life to load has been found to be approximately exponential, but of course different for each type. No definite fatigue limit is found for hardness about 60 Rc or higher.

The results of the torsion tests compared with life against Hertz pressures in bearings suggest that the fatigue failures in ball bearings are due to shear strains in the critical contact region under the ball track. The starting points of failures are usually located below the surface, and are often found at or near slag inclusions.

The Influence of Surface Roughness on the Fatigue Life and Scatter of Test Results of Two Steels. P. G. Fluck, University of Wisconsin.

This paper presents the results of tests on fatigue specimens of two different steels prepared by six different methods of surface finishing. The tests show a marked increase in fatigue life, as much as tenfold, due to polishing of the lathe-formed specimens.

Groups of twelve similar specimens were tested to provide information on the scatter or dispersion of test results. The specimens produced by the special method of gentle grinding described gave high and uniform results even though rather large longitudinal scratches remained on the specimens.

Effect of Residual Stress on the Fatigue Strength of Notched Specimens. D. Rosenthal and G. Sines, University of California.

Previous investigations have established that the residual stress definitely affects the fatigue resistance of metal parts, but no quantitative relations have been derived to predict the actual performance. In the present work an attempt was made to set up a basis for such a prediction by overcoming two of the major obstacles: (1) the presence of other factors, such as cold working or heat treatment, which are generally involved in the process of inducing residual stress, and (2) a partial relief of residual stress which can take place during fatigue testing. The tests were performed on notched 61S aluminum alloy in the precipitation hardened, 61S-T6 condition and in a softened condition. Residual stress, both compressive and tensile, has been set up at the base of the notch by a process of overstressing which created only negligible cold working, and the X-ray stress technique was used to follow up the change of residual stress during testing. While no change of residual stress was found in the 61S-T condition, in the softened condition the application of the fatigue load nullified any significant difference between stress free and prestressed specimens. On the other hand, the fatigue resistance of the hard alloy was influenced appreciably by the induced stress —increased in the case of residual tension—while it remained unchanged in the case of the soft alloy. A quantitative prediction of these results was made by combining X-ray data with the Goodman diagram of the unnotched.

Damping, Elasticity, and Fatigue Properties of Temperature Resistant Materials. B. J. Lazan and L. J. Demer, University of Minnesota.

The damping, elasticity, and fatigue properties of several temperature-resistant materials were investigated in rotating cantilever beam testing equipment. The room and elevated temperature tests were designed to reveal changes in damping energy and dynamic modulus of elasticity during constant cyclic stress fatigue tests at engineering stress levels. Usual *S-N* fatigue curves are presented in addition to a series of new diagrams designed to show the effects of both stress magnitude and stress history on the damping and elasticity properties. Two methods for comparing the damping energies of a group of materials are offered and the merits of each discussed. Diagrams are also presented to facilitate comparison of the elasticity properties among materials tested at a given temperature.

Damping, Fatigue and Dynamic Stress-Strain Properties of Mild Steel. B. J. Lazan and T. Wu, University of Minnesota. (To Be Presented by Title Only)

Damping energy, dynamic modulus of elasticity, and fatigue properties of mild steel are investigated in recently developed rotating beam testing equipment. Data on the effect of several important test variables, such as stress magnitude, stress history, frequency, and rest are presented. Stress magnitude and stress history data are analyzed in terms of cyclic stress sensitivity limit and stabilized damping points. These data are presented in S-N-N, S-N-D, and other new types of diagrams to indicate not only the fatigue behavior but also the damping and dynamic modulus properties. The effect of frequency of cyclic stress on damping and dynamic modulus is found to be considerable at stresses above the dynamic proportional limit. Dynamic stress-strain data are presented and analyzed to indicate the effect of stress magnitude and stress history on the dynamic proportional limit. Frequency sensitivity data are also presented in terms of strain rate and flow stress.

Laboratory Evaluation of Materials for Marine Propulsion Gears. M. R. Gross, U. S. Naval Engineering Experiment Station, Annapolis, Md.

This paper presents the methods used and the results obtained in evaluating the pitting resistance and root fatigue strength of marine gear materials. The pitting resistance of a variety of ferrous and non-ferrous materials was determined with contact roller tests which simulate the rolling action that occurs at the pitch line of a gear. A typical stress-cycle relationship is illustrated for ferrous materials and the pitting limits for various materials and treatments are tabulated. A so-called "simulated gear tooth fatigue test" has been developed for evaluating the root fatigue strength. This test procedure is described and results are presented for ferrous materials having several surface treatments and variations in the root radii and finish. The ferrous materials and treatments are rated and their use in marine gear calculations is discussed.

Paper on Weathering of Paints—Tuesday, June 19, 8:00 p.m.

Committee D-1 on Paint, Varnish, Lacquer, and Related Products will hold a special technical paper session at 8.00 p.m., Tuesday, June 19, at which time there will be presented a paper on Weathering of Paints, by R. J. Wirshing, General Motors Corp. It is felt that many ASTM members will be very much interested in this paper and therefore the committee is extending a cordial invitation to all those interested to attend.

See Abstract of Paper in News Section of Meeting

Symposium on Chemical Analysis of Inorganic Solids by Means of the Mass Spectrometer—Wednesday, June 20, 9.00 a.m.

At a special technical papers section of the meeting of Committee E-2 on Emission Spectroscopy, scheduled for 9.00 a.m., a "Symposium on Chemical Analysis of Inorganic Solids by Means of the Mass Spectrometer" will be given. All those interested are invited to attend.

Wednesday, June 20 9.30 a.m. Thirteenth Session

Methods of Testing

Report of Committee D-9 on Electrical Insulating Materials. A. H. Scott, Chairman.

Report of Committee D-3 on Gaseous Fuels. A. W. Gauger, Chairman.

Report of Committee D-5 on Coal and Coke. W. A. Selvig, Chairman.

Report of Committee E-8 on Nomenclature and Definitions. P. V. Faragher, Chairman.

Report of Committee E-1 on Methods of Testing. J. R. Townsend, Chairman.

The Constancy of Calibration of Elastic Calibrating Devices. W. C. Aber and F. M. Howell, Aluminum Company of America.

This paper describes the elastic load-calibrating devices used for calibrating testing machines throughout Aluminum Company of America and discusses the results of the calibrations of the devices by the National Bureau of Standards. Since 1933, when dead-weight equipment for the work became available at the Bureau, two Amsler calibrating boxes have each been calibrated nine times by the NBS. During that time the calibration factors for the devices have changed gradually but at the small rate of only about 0.1 per cent for three years of service. Two loop dynamometers, the deflections of which are measured with dial indicators, have remained practically constant since they were first constructed and calibrated in 1944. The importance of using dial indicators that will repeat readings within narrow limits is demonstrated.

Mechanical Properties in Torsion and Poisson's Ratio for Certain Stainless Steel Alloys. C. W. Muhlenbruch, Northwestern University, and V. N. Krivobok, and C. R. Mayne, International Nickel Co.

Modulus of elasticity in shear, shearing yield strength, and Poisson's ratio have been studied for a number of 300 series AISI stainless steels. The torque-twist relationships are nonlinear as are the tensile or compressive stress-strain diagrams. Values for secant shearing modulus of elasticity and a yield strength at a limiting amount of torsional strain are given as applicable to design problems. Work hardening reduces the shearing modulus and increases the shearing yield strength. Poisson's ratio for longitudinal specimens is almost constant with increasing stress up to, and in some cases beyond, the yield strength. The ratio increases with increasing stress for transverse specimens. Harder tempers have higher Poisson's ratios than softer tempers in the longitudinal direction. The reverse is true for the transverse condition. Reasons for these fundamental behaviors are advanced, based on an analysis of the stress-strain relationships; the susceptibility to work hardening, and the state of stress in the material when subjected to axial loading. The usual value of Poisson's ratio of 0.30 may be satisfactory in some cases but is in considerable error in others. A theoretical relationship between Poisson's ratio and secant moduli in tension and shear is presented.

An Arbitration Bar Izod Impact Test for Cast Iron. J. T. Eash, and A. P. Gagnebin International Nickel Co.

Wide interest has been shown in simple form of impact test and therefore, to assist others who may be interested in obtaining data in the same numerical system, dimensional constants of the machine are presented. Illustrative data are included which show that the system accommodates various types of cast iron with impact values ranging from 10 ft-lb for high phosphorus gray irons to over 120 ft-lb for austenitic cast irons. The impact results demonstrate the usefulness of the method both to develop the optimum composition and melting technique for new alloys and to assist in the selection of the material most suitable for particular engineering applications.

Electronically Excited Resonance-Type Fatigue Testing Equipment. T. J. Dolan University of Illinois.

An electrodynamic exciter is used to vibrate a U-shaped assembly, thus repeatedly bending a 1-in. diameter specimen which joins the two straight arms of the "U." Close control of the vibration is achieved with simple electrical circuits. Several unique design features are incorporated in the system that are applicable to exciting and controlling vibrations in other types of simulated service testing. Advantages and adaptability of the equipment are discussed; preliminary results are presented from fatigue tests of round and square specimens of 24S-T4 aluminum alloy.

Wednesday, June 20 11.30 a.m. Fourteenth Session

General Session—Featuring Speaker on Current National Problems

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Wednesday, June 20 2.00 p.m. Fifteenth Session

Effect of Temperature on Metals

Report of Committee A-1 on Steel. N. L. Mochel, Chairman.

Report of Committee A-3 on Cast Iron. J. S. Vanick, Chairman.

Report of Committee A-7 on Malleable-Iron Castings. W. A. Kennedy, Chairman.

Report of Joint Committee on Effect of Temperature on the Properties of Metals. Ernest L. Robinson, Chairman.

Creep-Rupture of Several Sheet Steels. G. V. Smith, E. J. Dulis, and E. G. Houston, U. S. Steel Corp.

Grips for testing sheet or strip specimens in creep-ruptures are described and experimental results reported for the following materials and test temperatures: (1) annealed 18 Cr–8 Ni–Mo steel at 1100, 1300, and 1500 F.; (2) annealed and half-hard 17 Cr–7 Ni steel at 600 and 1100 F., and (3) cold-rolled 4608 (Ni-Mo) steel at 600 F.

Fabrication of Chromium-Molybdenum Steel Piping for 1000–1050 F. Central Station Service. R. W. Emerson, Pittsburgh Piping and Equipment Co.

Effect of hot fabrication such as upsetting, hot bending, forging, and welding on the mechanical and metallographic properties of 2 per cent Chrome–½ per cent Moly, 2¼ per cent Chrome–1 per cent Moly, and 3 per cent Chrome–1 per cent Moly steel and the removal of same by final heat treatment are described. The effect of heat treating temperature, cooling rate and deoxidation practice on grain size and structure of these materials is also discussed together with their attending influence on structural stability following prolonged service temperatures.

Microstructural Instability of Steels for Elevated Temperature Service. G. V. Smith, W. B. Seens, H. S. Link, and P. R. Malenock, U. S. Steel Co.

Paper describes the effect of exposure for 10,000 hr at 900, 1050, or 1200 F. on microstructure, hardness at room temperature, and notch-impact strength at different temperatures of 18 ferritic and austenitic steels which may be applied in service at elevated temperature.

Notch-Toughness of Four Alloy Steels at Low Temperatures. W. B. Seens, W. L. Jensen, U. S. Steel Co., and O. O. Miller, International Nickel Co.

Charpy keyhole-notch specimens from four steels of interest for service at low temperatures were tested at temperatures ranging from room temperature to −315 F. These steels are 2215 (2.5 per cent Ni), 2317 (3.5 per cent Ni), 4815 (3.5 per cent Ni–0.25 per cent Mo), and 2810 (9 per cent Ni). For these steels in the form of plate, the results show the effect of test temperature, specimen location, and orientation in the plate, plate thickness, and heat treatment after hot rolling, on energy absorbed in the Charpy test. Data for subsize specimens from 2317 and 2810 steel tubing also are presented.

Apparatus for Low Temperature Tension Tests of Metals. R. J. Mosborg, University of Illinois.

This paper presents a brief description of the testing equipment and procedure which have been developed at the University of Illinois for tensile tests at low temperatures. With the use of a bath of liquid nitrogen for tests at −321 F. and a bath of Freon 12 cooled with liquid nitrogen for tests between −90 and −230 F., the testing procedure proved to be both convenient and efficient. The use of a Dewar flask as a part of the testing apparatus eliminated additional handling or transfer of the liquid nitrogen and resulted in considerable economy.

Notch Toughness of Fully Hardened and Tempered Low Alloy Steels. R. L. Rickett and J. M. Hodge, U. S. Steel Co.

Results of room-temperature Charpy keyhole-notch impact tests of a large number of quenched and tempered low-alloy steels are presented. From the results of these tests it is concluded that, when quenched and tempered to the same hardness, low-carbon steels are generally tougher, when notched, than medium-carbon or higher-carbon steels. A more limited number of tests made at lower temperatures show that at these temperatures, also, 0.3 per cent carbon steels tend to be tougher than 0.4 per cent carbon steels. In addition, these tests demonstrate that tempering at about 600 F. generally results in inferior notch-toughness, both at low temperatures and at room temperature.

Wednesday, June 20 4.00 p.m. Sixteenth Session

Marburg Lecture, Dudley Medal, and Awards

Marburg Lecture—Corrosion Testing. F. L. LaQue, International Nickel Co.

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering materials. Established as a means of emphasizing the importance of the function of the Society of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secretary of the Society, who placed its work on a firm foundation and through his development of the technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials.

Charles B. Dudley Medal

Richard L. Templin Award

Sam Tour Award

Wednesday, June 20

Cocktail Party 6.30 p.m.

and

Annual Meeting Dinner 7.30 p.m.

The Philadelphia District, through its Council, is again acting as the official host for the Annual Meeting. It has arranged a Cocktail Party and informal Dinner at which there will be some outstanding entertainment. Based on experience of the past two years, the Council believes that the members will welcome some period during the Annual Meeting of a distinctly social nature and therefore, with the approval of the Society officers, has arranged this feature. The Cocktail Party will be on a "dutch" basis, starting at 6:30 p.m. in the Carolina Room, with dinner to follow at 7:30. There is to be music throughout, and following dinner several interesting and coordinated entertainment acts, by outstanding performers, will be presented. Dancing will follow. A form for dinner reservations will be mailed to members late in May.

The Philadelphia District Council is also arranging for Ladies' Entertainment, and a program which will be interesting and attractive for the ladies is being developed.

Thursday, June 21 9.30 a.m. Seventeenth Session

Held Simultaneously with the Eighteenth Session

Concrete

Report of Committee C-3 on Chemical-Resistant Mortars. F. O. Anderegg, Chairman.

Report of Committee C-4 on Clay Pipe. J. C. Riedel, Chairman.

Report of Committee C-9 on Concrete and Concrete Aggregates. Kenneth B. Woods, Chairman.

Sanford E. Thompson Award to R. C. Mielenz, L. P. Witte, and O. J. Glantz.

Report of Committee C-12 on Mortars for Unit Masonry. J. M. Hardesty, Chairman.

Report of Committee C-13 on Concrete Pipe. W. W. Horner, Chairman.

Freeze-Thaw Resistance of Concrete as Affected by Alkalies in Cement. Bailey Tremper, Department of Highways, State of Washington.

Data of a large number of freezing-thawing tests of concrete containing aggregates from Rock Island, Washington, are presented together with similar tests using aggregates from Steilacoom, Washington. Resistance to freezing and thawing is shown to be increasingly poor as the alkali content of the cement is increased. Concrete containing Rock Island aggregates is more seriously affected by alkalies than is that containing Steilacoom aggregates.

Rock Island aggregates contain traces of saponifiable organic matter which causes the entrainment of small amounts of air in proportion to the alkali content of the cement. The air thus entrained tends to improve resistance to freezing and thawing but is not formed in sufficient quantity to counteract the inherently poor resistance brought about by the use of high-alkali cement. Additional entrained air introduced by an air-entraining agent improves the resistance to a value that is apparently satisfactory.

Aggregate Tested by Accelerated Freezing and Thawing of Concrete. W. H. Price and D. G. Kretsinger, Bureau of Reclamation.

The automatic freezing and thawing apparatus used for testing concrete in the laboratory of the Bureau of Reclamation at Denver is described and the results are compared with those obtained with the manually operated apparatus used prior to 1946. The procedure employed in determining the suitability of aggregates by testing them in concrete subjected to alternate cycles of freezing and thawing is outlined, and the results obtained with aggregates from a number of projects are presented. The effect of variation in the test procedure on results is discussed.

Performance of Automatic Freezing and Thawing Apparatus for Testing Concrete. Stanton Walker and D. L. Bloem, National Sand and Gravel Assn.

An automatic machine for subjecting concrete test specimens to freezing and thawing is described, together with data of its performance. The paper is introduced by a summary of factors affecting the results of freezing and thawing tests which should be taken into consideration in the design of apparatus for such tests. The automatic machine described is believed to be unique in that it can be used to freeze specimens either in air or in water as desired. It has a capacity of fifty 3 by 4 by 16-in. concrete beams; eight or more cycles may be secured each day if freezing is in air; the number of cycles is reduced to six or seven when freezing is in water.

Some Properties Affecting the Abrasion Resistance of Air-Entrained Concrete. L. P. Witte and J. E. Backstrom, U. S. Bureau of Reclamation.

Sixty-six concrete mixes covering a range of eleven water-cement ratios varying from 0.40 to 0.70 by weight and six air contents varying from 0.2 to 16.8 per cent were included in this investigation to determine the effect of entrained air and other properties on the abrasion resistance of concrete. The results of these tests showed that, in general, equal abrasion resistance was obtained for concrete of equal strength irrespective of the air content or density of the concrete. Results of the shotblast test, which was used for comparing the abrasion resistance of the concrete in this investigation, are correlated with the erosion obtained under exposure to the forces of the cavitation in water flowing at high velocities.

Permeability Tests of Lean Mass Concrete. H. K. Cook, Waterways Experiment Station.

The design and operation of permeability test equipment for testing 14½ by 15-in. cylindrical specimens at 200 psi pressure are described. Permeability coefficients of specimens representing nine air-entrained containing 2½-in. aggregate but with water-cement ratios equal to those for full mass mixes with 6-in. aggregate and with cement factors of from 2.00 to 3.00 bags per cubic yard are reported after testing at ages of three months and one year. Plans for testing at later ages and for the testing of other specimens are described.

Use of the Soniscope for Measuring Time of Set of Concrete. E. A. Whitehurst, Purdue University.

The proposed paper will report the results of recent tests made with the soniscope upon freshly placed concrete. The soniscope itself has been previously reported to the ASTM by J. R. Leslie.

In these tests, concrete of very stiff consistency was cast into 4 by 4 by 16-in. beams. The end plates of the molds were removed immediately after the concrete was in place. By means of the soniscope, the velocity of vibration propagation through the specimens was measured at regular intervals, usually ½ hr. It was found that this velocity was very low (in the order of 4000 ft per second) shortly after the concrete was placed.

Four cements, conforming to ASTM Types I, II, III, and IV, were used in this study. The times of final set of these cements varied from 4 hr; 15 min. to 8 hr.

Thursday, June 21 9.30 a.m. Eighteenth Session

Held Simultaneously with the Seventeenth Session

Non-Destructive Testing, Appearance, Non-Ferrous Metals, Creep, Corrosion-Resistant Alloys

Report of Committee B-6 on Die-Cast Metals and Alloys. J. R. Townsend, Chairman.

Aluminum Die Castings—The Effect of Process Variables on Their Properties. W. Babington, Bell Telephone Labs., Inc., and D. H. Kleppinger, Frankford Arsenal.

Groups of aluminum-alloy die castings were made under varying conditions of injection pressures, gate thicknesses, plunger speeds, and venting. These castings were made in a special test casting die previously designed by another ASTM group. Accurate measurements and recordings of plunger speed, metal pressure in the die, and temperature of metal and die were made by means of specially designed instrumentation. The castings produced were examined visually and radiographically and were subjected to mechanical tests. The data from these tests have been correlated with the casting conditions and certain conclusions drawn.

Report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. Jerome Strauss, Chairman.

Report of Committee B-2 on Non-Ferrous Metals and Alloys. Bruce W. Gonser, Chairman.

Report of Committee B-7 on Light Metals and Alloys, Cast and Wrought. I. V. Williams, Chairman.

Report of Committee E-2 on Emission Spectroscopy. B. F. Scribner, Chairman.

Report of Committee E-3 on Chemical Analysis of Metals. H. A. Bright, Chairman.

Report of Committee E-4 on Metallography. L. L. Wyman, Chairman.

Report of Committee E-7 on Non-Destructive Testing. J. H. Bly, Chairman.

Report of Committee E-12 on Appearance. M. Rea Paul, Chairman.

The Creep Properties of Two Tempers of 63S Extruded Aluminum Alloy. O. D. Sherby and J. E. Dorn, University of California.

The creep and stress-rupture characteristics of 63S extruded aluminum alloy in the T5 and T6 tempers (ASTM Alloys GS10A-T5 and GS10A-T6, respectively) were obtained at 90, 212, 300, and 400 F. up to 1000 hr. rupture time. Within the range of secondary creep rates tested, the creep properties of 63S-T6 (GS10A-T6) were superior to those of 63S-T5 (GS10A-T5) over all conditions of test that were investigated. At 300 and 400 F., however, the creep resistances of the two materials approached each other at the lower creep rates.

Effect of Annealing on the Creep Properties of 2S-O Alloy. O. D. Sherby and J. E. Dorn, University of California.

The effect of stabilizing anneals at 650 F., 950 F., and 1150 F. on the creep properties of 2S-O alloy was investigated. Large grains were produced by the 1150 F. annealing treatment but the other two annealing temperatures produced no grain growth and were essentially recovery treatments. The creep rate was found to decrease with increasing temperature of anneal, irrespective of grain size, within the ranges of stress and temperature which were investigated. The increase in creep resistance by annealing was ascribed primarily to greater grain perfection and not to grain size *per se*. A theory, based on dislocation, was presented in quantitative agreement with the experimental results.

The Creep Properties of Some Forged and Cast Aluminum Alloys. O. D. Sherby, T. E. Tietz, and J. E. Dorn, University of California.

The creep and stress-rupture properties of the following aluminum alloys were obtained for 90, 212, 300, 400 F. up to 1000 hr. rupture time:

Forgings: B18S-T61, 18S-T61, A51S-T6.
Permanent Mold Castings: 355-T71, A132-T551, 333-T533.
Sand Castings: 355-T71, 142-T77, A355-T51.

The above sequence of alloys in each group is the sequence of decreasing resistance to creep and stress-rupture over the range of conditions which were investigated. Although the permanent mold casting 355-T71 had higher creep and stress-rupture resistance than the sand casting alloy 355-T71 of the same composition at 90 to 300 F., the difference between the two alloys was negligible at 400 F., suggesting that at yet higher temperatures the sand casting alloy might exhibit superior creep properties to the permanent mold alloy. It is believed that these observations are attributable to the coarser grain size and dispersion of intermetallic compounds in the sand cast material.

Thursday, June 21 2 p.m. Nineteenth Session

Held Simultaneously with the Twentieth and Twenty-first Sessions

Plastics

Report of Committee D-1 on Paint, Varnish, Lacquer, and Related Products. W. T. Pearce, Chairman.

Report of Committee D-16 on Industrial Aromatic Hydrocarbons. D. F. Gould, Chairman.

Report of Committee D-20 on Plastics. G. M. Kline, Chairman.

Properties of Exposed and Unexposed Polyvinyl Butyral Coated Fabrics. M. I. Landsberg, T. J. DiFilippo, and L. Boor, Philadelphia Quartermaster Depot.

Physical properties, plasticizer and phosphorus contents were obtained before and after Florida exposure on a series of polyvinyl butyral resins plasticized with varying amounts of approximately equal parts of trioctyl phosphate and dibutyl "cellosolve" sebacate.

It is shown that the most important variable in its effect on the coated fabric was the modulus of the coating compound in the final cured form.

It is shown that approximately 360 ultraviolet hours of exposure are required to seriously degrade these materials.

Plasticizer and phosphorus ratio determinations indicated that the dibutyl "cellosolve" sebacate is lost at a much faster rate than the trioctyl phosphate and that the ultimate loss of the former is also much greater than that of the latter.

Creep Test Methods for Determining Cracking Sensitivity of Polyethylene Polymers. J. D. Cummings and W. C. Ellis, Bell Telephone Labs., Inc.

Two test methods for determining the cracking sensitivity of polyethylene polymers have been described; one, utilizing strip-tension specimens, is particularly applicable for appraisal of materials in an experimental program; the other, using internal pressure in a pipe sample, is applicable to polymers manufactured in the form of tubes.

The methods of stressing produce polyaxial or biaxial stress required for cracking to occur. In the pipe sample no artificial notching is necessary and the biaxial stress can be calculated. Both tests are modifications of conventional creep test methods.

Polyethylene polymers of different plasticity numbers were rated as to crack resistance. Crack resistance increased with plasticity number and, therefore, with increase in average molecular weight range.

Creep Relaxation Relations for Styrene and Acrylic Plastics. J. Marin and Yoh-Han Pao, The Pennsylvania State College.

Thursday, June 21 2 p.m. Twentieth Session

Held Simultaneously with the Nineteenth and Twenty-first Sessions

Symposium on Measurement of Consumer Wants

ASTM's Administrative Committee on Ultimate Consumer Goods has found that standards for such goods must be based on what consumers want. Accordingly, they have arranged this symposium to acquaint engineers with scientific development in this field. In the first session representatives of the U. S. Quartermaster Corps will discuss problems associated with determining soldier wants. The second session will cover researches in measuring consumer wants. The latter session has been arranged with the cooperation of Dr. Pendleton Herring of the Social Science Research Council. The researches being reported relate to part of the activity of a Joint Committee of the National Research Council and the Social Science Research Council, of which Samuel A. Stouffer of Harvard University is Chairman.

Determination of Soldier Wants. W. C. Schaefer, University of Maryland.

Objective research methods which will insure predictability and control of efficiency of usage, supply, design, and logistics are essential to Quartermaster Corps activities.

Indoctrination and accustomization studies include investigation of techniques of accommodating and adjusting men to the necessary design, bulk, and weight of Quartermaster Corps items of supply and techniques of indoctrination of men toward maximally effective utilization of Quartermaster Corps items of supply.

Some high lights of the problems and proposed solutions at this time will be presented.

Determination of Soldier's Food Wants. R. Palmer Benedict, Office of the Quartermaster General.

Modern techniques of consumer requirement research have been applied to find the relative acceptability of the several hundred dishes that are served in Army messes. Special sampling procedures developed for troop attitude research in connection with morale studies were employed. It was found that some foods were accorded rankings somewhat different from those expected.

Pilot study was made on consumption rates at a number of mess halls over an extended period. Results are characterized by wide day-to-day variation in consumption within each mess hall. Some interesting side lights were obtained on individual consumption of certain items.

Discussion. David R. Peryam, Quartermaster Corps.

The presentation of material relating to different problems of the measurement of human values usually raises more questions than it answers, which indicates a healthy condition for a new discipline. New ideas are brought to attention and time-honored problems may be seen in a new light. This tends to stimulate audience participation and the discussion period will provide its opportunity. There will be inquiry into the theory and the supporting assumptions of the methods that have been described—an interchange of ideas about them. It is anticipated that the possibilities of their interpretation and application in industrial practice will get particular attention.

(Continued in Twenty-second Session)

Thursday, June 21 2 p.m. Twenty-first Session

Held Simultaneously with the Nineteenth and Twentieth Sessions

Cementitious Materials, Asphalts

Report of Committee C-1 on Cement. R. R. Litehiser, Chairman.

Report of Committee C-2 on Magnesium Oxychloride and Magnesium Oxysulfate Cements. Chairman, L. S. Wells.

Report of Committee C-8 on Refractories. R. B. Sosman, Chairman.

Report of Committee C-16 on Thermal Insulating Materials. E. R. Queer, Chairman.

Report of Committee C-18 on Natural Building Stones. L. W. Currier, Chairman.

Report of Committee C-21 on Ceramic Whiteware. J. H. Koenig, Chairman.

Report of Committee C-22 on Porcelain Enamel. W. N. Harrison, Chairman.

Changes in Characteristics of Portland Cement as Exhibited by Laboratory Tests Over the Period 1904 to 1950. H. F. Gonnerman and William Lerch, Portland Cement Assn.

This paper describes the changes in composition, fineness, and strength-producing characteristics of type I portland cement as exhibited by laboratory tests over the period 1904 to 1950. The principal changes have been an increase in computed tricalcium silicate content and an increase in fineness, each of which has contributed to higher concrete strengths at all ages up to ten years, the latest age of test reported in the paper. Most of these changes occurred during the period 1926 to 1940. It is particularly noteworthy that, although the changes in composition and fineness have greatly increased the strength at early ages, the gain in strength of moist-cured concrete from 28 days to 10 years has remained approximately the same—3250 psi.

Included in the paper are data comparing composition, fineness, strength-producing characteristics, volume change, heat of hydration, and sulfate resistance of the five types of portland cement covered by ASTM Specification C 150.

The Use of an Increased Cement Factor in High Early Strength Concrete. P. L. Melville, Virginia Council of Highway Investigation and Research.

Method of Making Vibrated Dry-Tamp Concrete Cylinders Applied to Tests of Lightweight Aggregate and Block Mixtures. S. B. Helms and A. L. Bowman, Lehigh Portland Cement Co.

Inexpensive equipment is used to consolidate 3 by 6 in. cylinders by vibration and simulate a concrete block structure. Specimens are found reproducible and superior to hand-compacted units with disadvantages of fictitious high strength, over densification, and particle fracture eliminated.

Results from three test programs are reported: Four lightweight aggregates with identical gradings were studied in 24 block/sack concrete. Results show the effect of increasing the 100 mesh dust in the No. 8 mesh fine aggregate from 5 to 25 per cent.

The effect of air-entraining cement on the properties of dry-tamp expanded slag concrete was investigated at 24 block yields. Types I, IA, III, and IIIA cement were included in the program.

The cements from latter were used to prepare sand and gravel concretes at 24 block yield. Units of 30 block yield were also made with the high early cements. Cylinders were subjected to 175 cycles of freezing and thawing. Photos of the exposed specimens are included.

A Study of Aged White Coat Plaster by Differential Thermal Analysis. J. A. Murray and H. C. Fischer, Massachusetts Institute of Technology.

White coat plasters, prepared from 16 commercial hydrated limes, were subjected to differential thermal analysis at ages up to one year. Significant differences were found between the several hydrates, particularly in regard to such factors as the rate of carbonation of the $Ca(OH)_2$ portion of the plaster, the rate of hydration of the MgO portion, and the retention of free and adsorbed water. Evidence pointing to the delayed hydration of calcium sulfate hemihydrate was found in a few cases while in some of the plasters indications were found of slow dehydration of gypsum at the later ages.

Positive evidence of the carbonation of the magnesium hydroxide fraction was unobtainable under the experimental conditions although some peculiarities in the thermograms suggest this possibility. The formation of magnesium sulfate heptahydrate in dolomitic plasters subjected to wet storage conditions is believed to have occurred.

Report of Committee D-4 on Road and Paving Materials. C. E. Proudley, Chairman.

Report of Committee D-8 on Bituminous Waterproofing and Roofing Materials. A. J. Steiner, Chairman.

Progressive Heterogeneity on Aging, in Naphtha Sols of "Negative Spot Test" Asphalts. G. L. Oliensis, Lloyd A. Fry Roofing Co.

In an ASTM paper in 1941 it was shown that the more homogeneous the internal structure of an asphalt was, the longer would be its "negative period" (the time required for its spot-test sol to turn positive), and the latter value was reported for 18 of the 39 asphalts studied whose end point had by then been reached. During the 10 years since elapsed, 15 of the remaining 21 asphalts have attained this end point.

This paper presents (*a*) a tabulation of all negative period values so far obtained, (*b*) a 10-yr. comparison between "negative period" and "hexane resistance" values, (*c*) a study of the comparative effectiveness of commercial hexane and pure normal hexane for the determination of "hexane resistance," (*d*) the bearing of the foregoing data on the character of the flocculated bodies.

Thursday, June 21 8 p.m. Twenty-second Session

Held Simultaneously with the Twenty-third Session

Symposium on Measurement of Consumer Wants (Continued)

The General Problem of Measurement. Samuel A. Stouffer, Harvard University.

Interviewer Bias. Clyde Hart, National Opinion Research Center, University of Chicago.

This paper will present a critical review of available methods of assuring reliability and validity of data collected from samples of human population through interviewing. The data presented will partially be substantiated by results of recent research. Attention will also be paid to the effect of other factors that may be present during the interview, and not merely to the interviewer bias in the narrower sense, that is, errors introduced into responses elicited from people, arising from the interviewer's own biases with respect to the subject matter.

Some Application of the Panel Technique in Social Research. Charles Y. Glock, Bureau of Applied Social Research, Columbia University.

Panel studies provide a unique means for measuring and interpreting social change. Three major types of cross-analysis of panel data to provide information on change can be distinguished. First, people can be characterized according to certain psychological or sociological attributes and the relative variability of their behavior or status can then be studied. Secondly, observed changes in attitude or behavior can be related to events which occurred in the interval between successive observations. Thirdly, changes in one attitude or behavior pattern can be cross-analyzed against changes in another. The implications of these several approaches to the analysis of panel data will be treated in some detail.

Effective Sampling Procedures. F. F. Stephan and P. J. McCarthy, Princeton University.

Excellent techniques for sampling human populations and various groups of people within a population have been developed in recent years. Their application to problems of measuring opinions, preferences, and other psychological variables involves certain particular problems of selection, cooperation, and performance as well as the general problems of survey design. Current analyses of experience in sampling operations and a number of special research investigations are improving the effectiveness of these techniques and testing their dependability in use under various conditions.

Thursday, June 21 8 p.m. Twenty-third Session

Held Simultaneously with the Twenty-second Session

Symposium on Structural Sandwich Construction

Structural sandwich constructions, as usually employed, consist of laminated materials in which the faces are relatively thin, strong, and dense, whereas the cores are relatively thick, light, and considerably weaker than the faces. The more or less obvious objective is to obtain a structure which is strong and stiff because of its construction, but is at the same time light in weight, or has other desirable attributes not obtainable with the components alone.

A great deal of effort has gone into the development of structural sandwich constructions, primarily for the transportation and building industries. In aircraft, in particular, research and development have been most intensive, but the building industry also makes major use of such assemblies or walls, partitions, and other parts of buildings.

The American Society for Testing Materials recognized the growing need for test methods and specifications for this relatively new field, and therefore set up Committee C-19 to handle these requirements. Committee C-19 has arranged this symposium for the benefit of all who are interested in obtaining a wider acquaintance with these constructions, and to act as a forum for discussion.

Developments and Trends in Lightweight Construction. L. J. Marwardt, Forest Products Laboratory.

Sandwich Construction in the Elastic Range. H. W. March, Forest Products Laboratory.

A brief survey is made of a selected group of problems concerned with the elastic behavior of sandwich construction. These include the wrinkling of the facings under compressive load and the effect of shear deformation in the core on the deflection of uniformly loaded panels and on the buckling loads of panels subjected to edgewise compression or shear. In order to show the characteristic features of the behavior of sandwich construction in as simple form as possible, formulas and curves are presented for such constructions with isotropic facings and cores. Reference is made to the corresponding results for orthotropic materials.

Strength of Sandwich Construction. Charles B. Norris, Forest Products Laboratory.

A number of modes of failure that are peculiar to sandwich construction are described and their relations to allowable stresses and allowable loads are discussed. For purposes of simplicity and brevity the discussion is limited to strips of sandwich construction loaded as beams or columns.

Compressive and Torsional Instability of Sandwich Cylinders. George Gerard, New York University.

A review of a theoretical and experimental program on the buckling behavior of sandwich cylinders is presented. The two types of instability which can occur for a sandwich element are considered. One type involves buckling of the sandwich element as a unit and the other is concerned with the buckling of the faces upon the core which is commonly referred to as wrinkling. Both types are considered theoretically for the sandwich cylinder under compressive and torsional loadings and experimental data on buckling loads and buckle patterns are offered to substantiate the theoretical results.

Paper Honeycomb as a Core for Structural Sandwich Construction. Edward W. Kuenzi, Forest Products Laboratory.

This paper summarizes the work done at the Forest Products Laboratory on different types of paper cores for use in aircraft and for house sandwich constructions. Discussions are given of the manufacturing processes and, finally, the results of tests of core materials made from several papers containing various kinds and quantities of resin. Conclusions of a theoretical analysis are presented for predicting the compressive and shear strength of the aircraft-type paper core. Included in a discussion of core materials for housing are the results of tests of strength, thermal insulation, decay, and actual exposure to the weather in a test unit.

Aluminum Honeycomb Sandwich Construction. T. P. Pajak, The Glenn L. Martin Co.

Aluminum honeycomb core material has outgrown the experimental stage and is used on production structures. The combination of aluminum facings, aluminum core, and a specially developed adhesive results in a structural material with desirable high strength and rigidity characteristics. The advantages of the aluminum honeycomb core material are uniform density, high specific strength, high shearing modulus, and resistance to environmental effects with constant strength under variable humidity and temperature conditions.

The strength of aluminum honeycomb core varies directly with the density of the core regardless of the various combinations of cell sizes and foil thicknesses. Standardization of cell size has resulted in volume production of core material and increased applications. Proper design and fabrication process control are required to achieve satisfactory results. An impressive variety of aircraft parts has been made of aluminum core and recent trends indicate that an increasing percentage of new airframe designs are utilizing aluminum honeycomb sandwich construction.

Some Developments in Structural Sandwich Building Panels Having Inorganic Cores. G. M. Rapp, John B. Pierce Foundation.

The history of the development of sandwich constructions in the fields of aeronautics, radar, and motor transport is compared briefly with that in the building industry. The basic differences between design technologies, materials, and economics in these two broad fields, which distinguish *building* sandwiches, are pointed out. Laboratory research and developments in sandwich building panels employing core materials of the rigid inorganic type—specifically, cellular glass and low density calcium hydrosilicate (lime-silica)—are described. The results of structural tests of full-size panels in static and impact flexure are presented and analyzed in terms of application requirements. It is shown that sandwich compositions using these core materials, 2 in. thick, faced with either thin plywood, asbestos-

cement board, or steel-surfaced hardboard, have static and impact flexural strength and stiffness adequate for many building uses.

Fabrication Techniques for Structural Sandwich Constructions. Bruce G. Heebink, Forest Products Laboratory.

The discussion will feature principally the fabrication of lightweight sandwiches for aircraft applications such as wing coverings, floors, shear webs, and radar antenna housings.

Consideration will also be given to fabrication of sandwiches for housing, furniture, and transportation applications. Such widely different materials as glass cloth, metals, plywood, and paper for facings; and cores of solid wood, metal honeycomb, and synthetic resin foams will be included. Bonding processes for the currently available metal-to-metal adhesives and low-pressure resins will be discussed. The various means of applying pressure and heat, including fluid pressure, and the limitations of each will be presented. Included also will be preparation details for core and facing materials such as means of cutting cores, cutting tolerances, metal cleaning methods, and means of applying adhesives. Nondestructive tests and inspection methods for quality of product may be touched on briefly.

Properties of Various Core Materials for Structural Sandwich Construction. Edward W. Kuenzi, Forest Products Laboratory. (To Be Presented by Title Only)

Friday, June 22 9.30 a.m. Twenty-fourth Session

Symposium on Acoustical Materials

The problem of noise in our modern civilization is a most important one. One of the most widely used and effective methods for controlling sound and reducing noise is through the proper use of acoustical materials. Although such materials are today being used extensively in a wide variety of applications, there are very few test methods for determining the properties of these materials which have been universally agreed upon or accepted. Because of this need the ASTM has recently decided to establish a new Committee C-20 to stimulate the formation of proper test methods and procedures. It is the primary purpose of this symposium to discuss briefly the origin and history of C-20 and to outline the many problems which it is attempting to solve.

Brief History of the Acoustical Materials Industry. Wallace Waterfall, Acoustical Materials Assn.

This paper will discuss the growth of the industry over the past thirty years, the present size of the industry, and the types and uses of its products. The reasons for organizing the Acoustical Materials Association and its present activities will be explained. The great importance to the industry of standardization of test methods will be stated.

Activity of Committee C-20. H. A. Leedy, Armour Research Foundation.

Because of the general interest shown in the establishment of an ASTM Committee on acoustical materials, a preliminary conference was called by ASTM Headquarters on February 17, 1949, which led to: (1) a recommendation to the ASTM Board of Directors that such a committee be organized; (2) the writing of a suggested program; (3) an organization meeting on May 3, 1949.

At the February 17 meeting, attended by 34 people representing a good cross-section of acoustical material manufacturers, consumers, and others, recommendations were made for five subcommittees; officers were elected; and a temporary organizing committee was appointed. Three meetings have subsequently been held, at which by-laws were approved and Subcommittees I—Sound Absorption, II—Fire Resistance, III—Maintenance, IV—Application, V—Other Physical Properties were activated.

The Measurement of Sound Absorption. Hale J. Sabine, The Celotex Corp.

The sound absorption coefficient of a material depends on its physical constants, such as flow resistivity, porosity, and thickness, on its surface condition, on the method of mounting, on the frequency of the sound, and on the angle of incidence of the sound wave. The three principal methods of measurement now in use, namely, reverberation chamber, box, and tube, are described, and the limitations of each with respect to frequency range, angle of incidence, representative sample size and mounting, and consistency are discussed. The work of Subcommittee I on Sound Absorption is outlined.

Combustibility of Acoustical Materials. Wallace Waterfall, Acoustical Materials Assn.

All degrees of combustibility of the industry products will be explained. Numerous methods for measuring combustibility have been suggested but there is little evidence that any of these indicate life hazard of the product in event of fire. The data which the industry now has will be indicated and it will be urged that Subcommittee IV of E-5 continue its work until a simple test method is developed and a realistic method of classifying materials adopted.

Maintenance of Acoustic Materials. Peter Chrzanowski and Albert London, National Bureau of Standards.

Application of Acoustical Materials. L. F. Yerges, United States Gypsum Co.

Nearly all acoustical materials today form an integral part of building construction or interior finish. Consequently, their performance characteristics of interest to us are not limited to sound absorption alone. Acoustical efficiency, performance, maintainability, etc., are all important.

The application of acoustical materials affects their acoustical efficiency, performance, structural integrity, fire resistance, thermal insulation and many other factors.

There are three general types of application of acoustical tile: (1) applied with adhesive, (2) nail or screw application, (3) mechanical methods.

Basic Physical Properties of Acoustical Materials. William Jack, Johns-Manville Research Center.

Acoustical materials are used in a wide variety of applications. In addition to their fundamental function of absorbing sound they are often required to be attractive and repaintable. Various degrees of resistance to humid conditions and fire hazard are required. Suitable methods for evaluating the properties important to the desired end results are discussed.

Report of Committee C-20 on Acoustical Materials. H. A. Leedy, Chairman.

Friday, June 22 11.30 a.m. Twenty-fifth Session

Report Session

Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. K. G. Compton, Chairman.

Report of Committee D-6 on Paper and Paper Products. W. R. Willets, Chairman.

Report of Committee D-7 on Wood. L. J. Markwardt, Chairman.

Report of Committee D-10 on Shipping Containers. T. A. Carlson, Chairman.

Report of Committee D-12 on Soaps and Other Detergents. J. C. Harris, Chairman.

Report of Committee D-13 on Textile Materials. W. D. Appel, Chairman.

Report of Committee D-14 on Adhesives. Frank W. Reinhart, Chairman.

Report of Committee D-15 on Engine Antifreezes. H. R. Wolf, Chairman.

Report of Committee D-17 on Naval Stores. V. E. Grotlisch, Chairman.

Report of Committee D-21 on Wax Polishes and Related Material. J. I. Hoffman, Temporary Chairman.

Report of Committee C-7 on Lime. W. C. Voss, Chairman.

Report of Committee C-15 on Manufactured Masonry Units. J. W. Whittemore, Chairman.

Report of Committee C-19 on Structural Sandwich Constructions. A. G. H. Dietz, Chairman.

Report of Committee D-2 on Petroleum Products and Lubricants. O. L. Maag, Chairman.

Report of Committee D-11 on Rubber and Rubber-Like Materials. Simon Collier, Chairman.

Report of Committee D-19 on Industrial Water. Max Hecht, Chairman.

Late in May each member and committee member will receive a reservation form for the Annual Dinner. It should be returned promptly.

ASTM Publications to Be Released During the Coming Months

(Late Spring and Summer)

Book of Standards:

Supplement Part 3, Book of Standards—Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, Soils

Compilations:

B-1 Compilation—Metallic Electrical Conductors
C-1 Compilation—Cement
C-8 Compilation—Refractories Manual
D-3 Compilation—Gaseous Fuels
D-9 Compilation—Electrical Insulating Materials
D-11 Compilation—Rubber and Rubber-Like Materials

Special Publications:

ASTM-IP Oil Measurement Tables
Bibliography on Electrical Contacts (revised, combined edition)

Symposiums and Technical Publications:

Symposium on Triaxial Shear Testing
Symposium on Measurements of Viscosity
Symposium on Thermal Insulating Materials ('51 Spring Meeting Symposium)
Data on High-Temperature Properties of Austenitic Steels

Index to ASTM Standards to Be Mailed During June

THE combined Index to the 1950 ASTM Book of Standards and all its 1951 Supplements, comprising about 275 pages, will become available during June and will then be mailed to each ASTM member and Committee Member.

The 1950 Index covers all the current standards in the six parts of the Book of ASTM Standards as well as those in the six Supplements. The standards are catalogued under suitable key words, and use is made of "see also" references so that the specifications are cross-referenced in as many subject fields as are applicable and important. These key words or "see also" references have been selected on an impartial, commonsense basis; the guide used in establishing these cross references is perhaps best explained by quoting a line from a popular song: "Doin' what comes natcherly."

The Index to Standards really has two basic uses, first, to determine whether or not the Society has issued any specifications, tests, or definitions on a particular material or subject, and, secondly, to note where the standards can be found.

In addition to sending the Index to members and committee members, it goes to extensive groups of purchasing agents, Government technical officials, and others interested in the field of materials. Many members procure a few extra copies for the use of their staffs, or for distribution to key technical personnel. There is no charge for it and anyone genuinely interested in ASTM standards can have his name added to the permanent Index mailing list so that he will receive the Index as issued each year.

Another valuable contribution to the Index is the list of standards in numeric order of their serial designation, and in these lists, reference is also made to the official source of the latest publication.

ASTM Manual on Quality Control of Materials Widely Distributed

THE Manual on the Quality Control of Materials prepared by the Society's Committee E-11 is being widely distributed. Orders for the 126-page book are being received from all sections of the country and abroad. It is designed to make available to ASTM members and others information regarding statistical methods and quality control methods and to make recommendations for their application in engineering work of the Society. The Manual consists of three Parts, of which Part I discusses the application of statistical methods to the problem of condensing the information contained in a single set of n observations, and presenting the essential information in a concise form. Part II explains the problem of presenting limits to indicate the uncertainty of the average, $\bar{X}$, of a unique sample of n observations, and suggests a form of presentation for use, when needed, in ASTM reports and publications. Part III gives formulas and tables useful in applying the "control chart" method of analysis of observational data obtained from several samples. The method provides a criterion for detecting lack of statistical control of quality.

The Manual, bound in heavy paper, is available at the price of $1.35 to members and $1.75 to nonmembers.

Symposium on Corrosion of Materials at Elevated Temperatures

THIS Symposium, sponsored by the Gas Turbine Panel of the ASTM-ASME Joint Committee on the Effect of Temperature on the Properties of Metals, resulted from an increasing awareness on the part of metallurgists and designers that the atmosphere in which a high-temperature component will operate must be carefully considered before a suitable material can be selected. In many cases, the corrosive aspects of the service will far outweigh the mechanical factors, such as creep and stress-to-rupture.

Many of the investigations presented in this Symposium were stimulated by gas-turbine developments, but unquestionably the work is applicable to other high-temperature activities. The papers have a wide range in scope and include both fundamental investigations of a general character and practical studies of a given problem.

The corrosion behaviors of materials in atmospheres from all the common fuels for mobile and stationary power generation are discussed, ranging from leaded aviation fuels to coal. The paper on corrosion by oil ash from residual fuels has attracted special interest because of the current seriousness of the problem in many industries.

The engineering materials studied in the various papers also present a wide variety and include mild steel at one extreme and ceramics at the other, with the multitudinous superalloys in between. Virtually all the materials currently in use in the power and fuels industry are included in one or more of the papers. Recent strategic developments will make the references on protec-

tive coatings and treatments of particular value.

The eight papers and their authors are as follows:

Coal Ash Corrosion of Metals at Elevated Temperatures—C. T. Evans, Jr., Elliot Co.

Stress Corrosion Tests on Turbo-Supercharger Materials in the Products of Combustion of Leaded Gasoline—G. B. Wilkes, Jr., General Electric Co.

Creep as a Surface Dependent Phenomenon—M. R. Pickus and E. R. Parker, University of California.

The Effect of Environment on the Stress-Rupture Properties of Metals at Elevated Temperatures—O. C. Shepard and W. Schalliol, Stanford University.

Preliminary Studies of the Effect of Oxidizing Sulfurous Atmospheres on the Rupture Strengths of Inconel "X" and Inconel—A. M. Talbot and E. N. Skinner, The International Nickel Co.

Hydrogenizing Effect of Steam on Ferrous Alloys at Elevated Temperatures—C. A. Zapffe and F. K. Landgraf, Consulting Metallurgists.

Oil Ash Corrosion of Materials at Elevated Temperatures—C. T. Evans, Jr., Elliot Co.

The Growing Role of Protective Coatings for Metals in High-Temperature Service—W. N. Harrison, National Bureau of Standards.

Copies of this 128-page profusely illustrated Symposium on Corrosion of Materials at Elevated Temperatures (STP No. 108) bound in heavy paper cover can be procured at $2.25 each; the member's price is $1.70.

Identification and Classification of Soils

THE symposium on the Identification and Classification of Soils, sponsored by ASTM Committee D-18 has recently been published. The purpose of this symposium is to describe the most widely used schemes for identifying and classifying soils for engineering purposes.

Until very recently no agreement could be reached by the engineering profession on the identification and classification of soils. The basis for this discrepancy lay in part in the fact that engineers are comparatively newcomers to the field of soil sciences and have therefore depended for advice on those engaged in agriculture, ceramics, and geology who have been interested in soils over a considerable period. But even those active in these fields had not been able to formulate a simplified identification system for classifying soils. It is hoped that this symposium will instill in the engineer the desire for obtaining a procedure that would satisfy the needs and requirements of all of those associated with the soil problems.

The papers presented in this symposium are as follows:

Identification and Classification of Soils—An Appraisal and Statement of Principles Classification of Soils as Proposed by the Bureau of Reclamation

Discussion of the Classification of Highway Subgrade Materials Initiated by the Highway Research Board

Soil Classification for Highway Purposes

Soil Series Names as a Basis for Interpretive Soil Classifications for Engineering Purposes

Comprising 96 pages, bound in heavy paper, the symposium sells for $1.65 to nonmembers and for $1.25 to members.

What Is a Good Abstract?

THE definition of a good abstract depends on what the abstract is to be used for. Some people expect an abstract to serve merely to "provide the knowledge of the existence" of a report. Others consider the abstract as a device to obviate the need for study of the report or article itself or, at least, give a detailed account of the subject matter contained. Such abstracts are then "digests or summaries" and are usually quite lengthy. The scope for abstracts as normally used by ASTM lies somewhere between the two extremes outlined above. The specifications for such a type of abstract are dictated by a number of considerations, one of which is to provide sufficient details so that the reader can decide whether the report merits acquisition and study.

Our abstracts, therefore, should provide the knowledge of the existence of a report; help the reader decide whether or not he should obtain and study the document, and finally serve as reference material. The abstract should not be too lengthy, but it should not be less than 100 words. The language used should be brief and concise, omitting all superfluous phrases and words. Brevity should not impair intelligibility and ease of understanding.

The abstract should always answer three questions: (1) What is the report or paper all about? (2) What is its scope? and (3) What are the conclusions reached or results obtained.

The abstract should not be a mere amplification of the title and must be intelligible without reference to it. The abstracter should not attempt to analyze, evaluate, or criticize the paper, but should present a clear and objective description. Highlights of the report should not be included unless they would help the reader decide whether or not the paper should be obtained and studied.

Safety Manual for the Die Casting Industry

THE American Die Casting Institute announces publication of a safety manual designed specifically for die casting plants. It covers step by step the entire area of a die casting plant and its specific safety procedure.

With the Manual aimed at the small and medium-sized plant, every attempt is made to present material in a manner that permits the small point to adopt the procedure. Safety is a responsibility of every plant regardless of plant size, number of machines, and number of employees. The Manual is designed for use by supervisors and foremen as an operating tool.

Printed on heavy stock $8\frac{1}{2}$ by 11 in., the Manual is presented in a cloth-covered loose-leaf binder to permit inclusion of in-plant programs. It is profusely illustrated and contains many prints of safety devices, control forms, and reference data. Distribution will start May 1.

Price $5 per copy, American Die Casting Inst., Inc., 366 Madison Ave., New York 17, N. Y.

ERRATA

ASTM Manual on Quality Control of Materials

ON PAGE 14 in Eq. 5 under the first radical the last term should be $\bar{X}^2$ rather than X^2. Following this on page 110, Eq. B1, in the equation for c_2 the square root sign should extend only over the fraction $\frac{2}{n}$. As corrected, the equation should read

$$c_2 = \sqrt{\frac{2}{n}}\,\frac{\left(\frac{n-2}{2}\right)!}{\left(\frac{n-3}{2}\right)!}$$

On the next page (111), Eq. B4 should be corrected to read $O_{\bar{X}} = \frac{o}{\sqrt{n}}$; in its present form "O" is missing from the expression to the left of the equal sign.

Symposium on Ultrasonic Testing

ON PAGE 70, second column, line 6 in a paper entitled "Basic Principles of Ultrasonic Testing" by J. C. Smack the phrase "length is approximately twice as long" should read "length is approximately one half as long." Since this particular paper is concerned with a subject where "one half as long" and "twice as long" might mean the acceptance or rejection of a material, the author wishes that this correction should get the widest publicity. After all, Mr. Smack, who in his opening statement mentioned the many thousand dollars which have been saved through the introduction of ultrasonic testing, wants to be sure that his figures and results will prove this.

National Bureau of Standards Celebrates Its Fiftieth Anniversary

THE National Bureau of Standards, created by the Act of Congress March 3, 1901, as a Center charged with "The Custody of the Standards," can look back on these past fifty years with great satisfaction. The Bureau has grown enormously in work and scope, and today its present staff is about 3300, its current annual budget $8,000,000. At the beginning of the Bureau's existence, plant and equipment was originally valued at $110,000; now they are assessed to be worth $55,000,000.

In the original act of Congress establishing the Bureau, it was specifically stated that beside being the Custodian of Standards, the NBS is charged with the comparison of standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the Standards adopted or recognized by the Government, the construction when necessary of standards, their multiples and subdivisions, the testing and calibration of standard measuring devices; the solution of problems which arise in connection with standards; and the determination of physical constants and the properties of materials.

Its unique research and testing facilities are used to discover and evaluate materials standards and to solve basic technical problems. The Bureau's work on standards of measurement is designed to assist in the standardization of containers and products, in promoting systematic inspection of trade weights and measures, and facilitates research in science and technology. The work on standards of quality sets up attainable standards and test methods to assure high utility in the products of industry. The Bureau also develops standards of performance, specifications for the operative efficiency or accuracy of machines or devices. Another service is the development of standards of practice, that is, collection of data and formulation of codes of practice for public utilities and other services.

It is especially of interest to note that more than 100 of the Bureau's staff are members of ASTM and that these men and many others are taking a very active interest in technical committee work. Since NBS and ASTM work closely hand in hand in regard to materials standards, it is only natural that many NBS scientists are heading ASTM committees.

National Metallurgical Advisory Board is Organized

FORMATION of a board of leading industrial and academic metallurgists to advise the Research and Development Board, Department of Defense, on research aspects of some of the nation's most critical metals problems has recently been announced.

Organized by the National Academy of Sciences–National Research Council under a contract with the Research and Development Board, the Metallurgical Advisory Board held its first meeting on February 7.

Within the limits of specific problem assignments, the metallurgists are to advise the Board on the correlation, coordination, interpretation, and application of metals research and development programs conducted or sponsored by the Military Services, suggests new research projects or reorientation of existing research, and collect and distribute such useful metallurgical information as can be gathered by the establishment of close liaison with the professional societies, governmental agencies, and academic and industrial organizations devoted to metals and their use.

Preliminary work by the Metallurgical Advisory Board is already in progress on research and development phases of three of the most urgent metals problems: (1) critical and strategic metals and their substitutes; (2) the application of metals to be used at high temperatures; and (3) development of the presently small titanium industry.

Among the metals in critically short supply listed tentatively for the study of the Metallurgical Advisory Board are columbium, tantalum, cobalt, titanium, molybdenum, tungsten, and beryllium. Other metals are, however, expected to be added to this list as the Board progresses in its preliminary studies.

Special project committees are to assist the Metallurgical Advisory Board, which also will have the cooperation of the military services, the Munitions Board and other Federal agencies actively interested in metallurgical problems.

Members of the Advisory Board are Dr. Robert F. Mehl, Head of the Department of Metallurgy, Carnegie Institute of Technology, Chairman; Dr. E. C. Bain, Assistant Vice-President, United States Steel Co.; Dr. John Chipman, Head Department of Metallurgy, Massachusetts Institute of Technology; Dr. Charles H. Herty, Jr., Assistant to the Vice-President, Bethlehem Steel Co.; Dr. Zay Jeffries, retired Vice-President, General Electric Co.; Walter E. Jominy Supervisor of Metallurgical Research, Chrysler Corp.; Dr. A. B. Kinzel, President, Union Carbide & Carbon Research Laboratories, Inc.; Dr. Paul D. Merica, Executive Vice-President, International Nickel Co.; Dr. Albert J. Phillips, Director of Research, American Smelting and Refining Co.; Leo F. Reinartz, Assistant Vice-President and Manager, Armco Steel Corp.; Dr. Cyril S. Smith, Director, Institute for Study of Metals, University of Chicago; Earle C. Smith, Chief Metallurgist, Republic Steel Corp.; Dr. Kent R. Van Horn, Associate Director of Research, Aluminum Company of America, and Dr. Clyde Williams, Director, Battelle Memorial Inst.

Ex-officio members of the Board are Dr. C. Richard Soderberg, Chairman, Division of Engineering and Industrial Research, National Research Council; Oliver C. Ralston, Chief Metallurgist, U. S. Bureau of Mines, and Dr. John G. Thompson, Chief, Metallurgy Division, National Bureau of Standards. Dr. Finn Jonassen, of the National Research Council, is Executive Secretary of the Metallurgical Advisory Board.

It is not expected that the Advisory Board will need to set up a broad functional organization to inaugurate programs and to cover all phases of the pertinent arts and sciences, as did the War Metallurgy Committee in World War II, but instead the new Board plans to operate on a special project basis so as to concentrate its capacities quickly and effectively on the most critical problems of metallurgy.

Under this new plan, Mr. V. H. Schnee, Vice-President, University of Oklahoma, and Director of the university's Research Institute, has become Executive Director of the Advisory Board. He will provide over-all administration of projects and supervise liaison with Government, industry, professional societies, and universities. Mr. William Mahin, Director of Research, Armour Research Foundation, has become Director of the Metallurgical Projects Division. Examples of current projects of first importance are high-temperature metals and titanium. Dr. Zay Jeffries will head the activities on critical and strategic metals and their substitutes.

Dr. Mehl in initiating the work of the Board, has expressed the opinion that a valuable contribution to the work of the Advisory Board could and would be made by the professional societies and the cooperation and assistance of the professional societies is enlisted.

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NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

The Materials Society or Avoiding Side Alleys

At the recent New England District Meeting in Hartford, Conn., Chairman H. H. Lester, a long-time ASTM member, emphasized to the some 140 individuals present, many of whom were attending their first ASTM meeting, that ASTM was *the* American *materials* society. He stated that professional and trade groups recognized this fact, and he wished to impress those at the meeting that this organization had concentrated its work, with outstanding results, in the *materials* field.

The chairman was not announcing any startling news, but we were impressed with the emphasis with which this outstanding leader in his field and an active participant in many professional groups made this statement. The presence of other acknowledged leaders, and authorities in their respective fields of work, including professional and trade activities, further emphasized the recognition of ASTM's eminence in this field.

Almost 50 years ago the path the Society was to follow and the rules for it were wisely conceived by an earlier group of leading men who recognized the necessity for some technical society to concentrate on developing authoritative data on the properties of materials and issue acceptable standards of quality and methods of evaluating materials.

Perhaps some of the strength inherent in ASTM and some of its success and outstanding accomplishments are traceable to the consistent policy of not straying far from the main road and not getting into side alleys. Not that there has been any lack of suggestions that we do so. For example, on more than one occasion the idea has been broached that the Society take unto itself the sponsoring of certain groups concerned with this or that phase of engineering activity. Perhaps much good would have resulted. But it would have involved in some instances professional problems and others that were of a nontechnical nature. The wisdom of the officers and members has dictated strict adherence to the primary purpose.

In this connection we are frequently reminded of a statement by the late Dr. Jewett of communications fame that, when he was an assistant to the research leader, General Carty, he was often disturbed and vexed frequently because of the concentrated and seemingly interminable efforts to ascertain all available facts bearing on a problem. Dr. Jewett said these searches frequently led him into side lanes and by-passes most interesting and instructive and sometimes profitable, but the main objective was not lost sight of.

There are some who, despite the effort to concentrate on our work detailed in the charter, feel that we may be getting into side alleys or trespassing on posted ground. Recently a leading engineering journal called us to task for what its associate editor felt was an undesirable incursion into the field of surface and subsurface soils exploration, on which an interesting symposium is to be held at the June meeting. Whether he took pains to consider this matter broadly, or recorded his observations as a result of attendance at a meeting of some other group, we do not know. However, comments of this kind are constructive in at least one sense—they do result in a careful re-examination of the situation. In this instance it is of interest that officers and members of the committee involved, competent leading men in their fields, are in full agreement that much good will come from the symposium being held. When a leading engineer in the Bureau of Reclamation, a state highway engineer for one of our leading commonwealths, a leading engineering professor in the field of soil mechanics, and another in highway engineering and responsible for an important highway research project, all speak out in strong support of the program, we rather feel that the project is not getting into too narrow a side alley and that it certainly won't have a dead end.

The ASTM approaches its 54th Annual Meeting. We are glad to be part of and associated with a group of over 10,000 men (and a few women) who *are* the Society—*the* materials society referred to above.

ASTM Receives ECA's Certificate of Cooperation

At a recent gathering at the office of Mayor Bernard Samuel of Philadelphia, Executive Secretary C. L. Warwick received for the Society a certificate given by the Economic Cooperation Administration in recognition of ASTM's assistance and cooperation in helping technical personnel from foreign countries to study U. S. and particular ASTM standardization. During the year 1950 there were 34 visitors to ASTM Headquarters from 12 foreign countries most visits being sponsored by ECA. Among these visitors was Jean Duval, Technical Director of the French Standards Assn., and Olle Sturen, Executive Secretary of the Swedish Standards Assn. A delegation of 15 men, comprising the "Netherlands Concrete Ware Products Team" conferred with one of our staff members at one of the local hotels. Five delegates from Germany were here to study the status of rubber research and standardization. Altogether, the delegations represented Australia, Belgian Congo, Denmark, England, France, Germany, Holland, India, Japan, South Africa, Switzerland, and Sweden. We can no doubt expect these international relations to increase over the years.

At the 1952 Annual Meeting in New York City for example, an international symposium on nondestructive testing is scheduled. Foreign papers to be presented will be on radiography, magnetic analysis, magnetic particle testing, and ultrasonics. A panel consisting of American experts will give a written discussion, prior to the meeting, on all the foreign papers.

Of the certificates being awarded by the Economic Cooperation Administration, the American Standards Association received a similar one at their recent spring meeting of the Board of Directors.

District Members Will Receive Ballots on Council Elections

IN MAY, each ASTM member and committee member in the respective ASTM Districts will receive from Headquarters a ballot on the election of District Councilors. This is in line with the Charter for Districts, which provides that a Nominating Committee of five members is to be appointed by the District Chairman, with Council approval, this group consisting of three non-councilors from the area and one Council or with the immediate Past-Chairman.

These Nominating Committees have been meeting and preparing their recommendations which will be submitted with the letter ballot. Provision is made on the ballot for writing in additional names for Council membership.

1951 being an odd year, there is no election of Council Officers. All ballots are to be returned to the District Secretary, full instructions being given with the ballot.

Standards—Spearhead of Industrial Mobilization

THE history of standardization shows that not only in 1917 to 1918 but also in 1941 to 1945, there was a decided stimulation of standardization. We should, however, not wait for a war period to accelerate standardization, but should keep going continuously. It is true that in some cases military specifications necessarily differ from commercial ones. It should, for example, be realized by industry that the high temperatures of the tropics, the severe low temperatures of the Arctic regions, the great humidity of the jungle area, the sand and dust frequently call for a departure from commercially developed standards. On the other hand, whenever military specifications can be assimilated with commercial ones no time should be lost in doing so.

Thus spokesmen from industry, military, and civilian agencies of the Government, labor and consumer groups discussed the crucial importance of standards to American rearming at the first National Standardization Conference, called by the American Standards Association. They reported on the already established standardization in national defense, company operations, procurement, construction and safety, and asked for increased efforts by all concerned to meet the challenge to production through standardization. The many papers presented by leading military, governmental, and industrial authorities dealt with Standards in Government and National Defense; Standards—A Procurement Tool; Standards in Construction, and Standards in Industry.

A special publication, containing all the papers presented at this conference, may be obtained from American Standards Association, 70 East 45th St., New York 17, N. Y., at $1 per copy.

Twenty-Eight New Sustaining Members

SINCE the first of the year 28 companies which have been affiliated with the Society through a company membership or in other ways have become ASTM Sustaining Members. A number of the companies responded favorably to a communication from President L. J. Markwardt which advised that the Board of Directors would appreciate their consideration of this class of membership—an important means of maintaining the Society's financial structure on a satisfactory basis. Through the annual dues of $150 the sustaining members are enabled to aid in underwriting the Society's technical activities to a degree which is in keeping with the value of the work to their activities.

Sustaining membership has the same privileges as a company membership which include the listing of the company's name in the Year Book, the privilege of designating different technically qualified individuals to serve on the diverse technical committees to which the company may be elected, and other features—and in addition each sustaining member has special publication privileges, for example, an extra complete set of the Book of Standards may be requested, as well as a copy of all ASTM publications, many of which are available only on purchase. Each sustaining member also receives a specially engrossed sustaining membership certificate.

The fact that well over 200 of the country's leading companies, each of them concerned vitally with ASTM work in materials, are sustaining members, has a two-edged connotation: First, a recognition by industry of the services of the Society; and secondly, an indication of the willingness of industry to cooperate and aid in carry-

New Sustaining Members

Alpha Portland Cement Co., J. F. Magee, President
American Brake Shoe Co., Raymond H. Schaefer, Vice-President and Director of Research and Development
Armour and Company, Victor Conquest, Director of Chemical Research and Development
Baltimore & Ohio Railroad Co., R. W. Seniff, Engineer of Tests
A. M. Byers Co., Edward B. Story, Chief Metallurgist
Continental Steel Corp., W. E. Buck, Metallurgical Engineer
Deere and Co., Hyman Bornstein, Chief Technical Consultant
Deering, Milliken and Co., Inc., W. R. Kuenzel, Director of Fabric Development
Eastern Gas and Fuel Associates William L. Glowacki, Research Chemical Engineer
General Portland Cement Co., E. L. Gibson, Vice-President
Great Northern Railway Co., W. R. Petry, Chemist
Hamilton Watch Co., G. E. Shubrooks, Chief Chemist and Metallurgist
Heppenstall Co., J. A. Succop, Metallurgical Engineer
Industrial Rayon Corp., Emil Kline, Chemical Control Manager
Johnson & Johnson, W. H. Lycan, Director of Research
Joy Manufacturing Co., T. H. Troller, Vice-President, Engineering
M. W. Kellogg Co., D. B. Rossheim, Assistant to Vice-President, Engineering
Minneapolis-Honeywell Regulator Co., Leonard Mayeron, Chief of Materials Div., General Engineering Dept.
Norfolk & Western Railway Co., G. E. Baumgardner Assistant Research Engineer
Pacific Gas and Electric Co., Everett V. Noe, Chief, Bureau of Specifications and Estimates, Department of Engineering
Schenley Distillers, Inc., Norman Kravitz, Quality Control Engineer
Scovill Manufacturing Co., Frederic M. Barry, Director of Research
Standard Steel Spring Co., G. B. Bowman, Chief Chemist
Swift and Co., V. C. Mehlenbacher, Assistant Chief Chemist, Research Laboratories
U. S. Industrial Chemicals, Inc., Norman C. Schultze, Head, Technical Service Div., Research and Development Lab.
United States Smelting, Refining and Mining Co., G. Howard LeFevre, Manager of Metal Sales
Universal-Cyclops Steel Corp., Frank Garratt, Vice-President and Technical Director
Weston Electrical Instrument Corp., N. C. Munisteri, Laboratory Sales Manager

ing on the Society's important work.

The new sustaining members since the first of the year are listed (certain of these have asked that their membership become effective January, 1952).

Emergency Standards Procedure

SEVERAL committees of the Society have found need for some special provisions to be made in their standards in view of the present emergency conditions. It is accordingly being proposed that an emergency procedure somewhat along the lines of that used during the recent war be instituted. In anticipation of consideration of this on the part of the Board, the Administrative Committee has reviewed the procedure that had been previously in effect, as a result of which, certain recommendations looking toward having a more adequate review of these emergency procedures are being developed. It is expected that the Board of Directors will take action on this matter in the near future.

E. R. Schwarz to Receive Smith Memorial Medal

PROFESSOR Edward R. Schwarz, Head of the Textile Division, Massachusetts Institute of Technology, is to receive the Harold DeWitt Smith Memorial Medal, at the October, 1951, New York meeting of ASTM Committee D-13 on Textile Materials.

The medal which is a testimonial to the memory of the late Harold DeWitt Smith, an outstanding textile scientist, has been made possible through the generosity of the Fabric Research Laboratories, Boston, Mass., and is awarded at intervals of not less than one year by Committee D-13.

The medal recognizes outstanding achievement in the field of textile fiber science and utilization which includes the development and promotion of knowledge of textile fibers and structures or methods for the evaluation of their properties.

About Professor Schwarz:

Born in the textile city of Lawrence, Mass.. Professor Schwarz attended M.I.T. studying textiles, but interrupted his studies to gain practical experience working in a textile mill. He received his degree in 1923 and remained at that institution becoming successively research assistant, instructor, associate professor, and finally, Professor of Textile Technology and Head of the Textile Division. He has contributed in major degree to the growth of textile research through his many investigations which embrace the physics and chemistry of various fibers as well as yarns and fabrics made from them. He has published many scientific articles and given many lectures.

During World War II he directed research in the Slater Laboratory at M.I.T., for the Army Air Forces and the Office of The Quartermaster General. He was a member of the Scientific Advisory Board to the Research and Development Branch, Military Planning Division, O.Q.M.G., member of the Advisory Board to The Aero-Medical Committee, and a consultant to the Textile Section of the War Production Board.

He served actively on the Advisory Committee for Scientific Research of the Textile Foundation, was director of the Textile Research Institute for ten years and Vice-President, 1935–1940. In 1947, he was given the Olney Medal, awarded for signal achievement, by the American Association of Textile Chemists and Colorists. In 1949 he was honored by being made a Fellow of the Textile Research Institute.

How Big Is an Inch?

By Senator Ralph E. Flanders

EDITOR'S NOTE.—A trenchant interesting article by Senator Flanders in January, 1951, *Atlantic Monthly*, explains why the standards of American industry should be initiated by industry itself. With the permission of the author and the *Atlantic Monthly*, we present a somewhat condensed version of this article. Senator Ralph E. Flanders carried both labor's and industry's endorsement when he ran as Senator from Vermont. He has been a designer and inventor of machine tools. For thirteen years he was President of The American Society of Mechanical Engineers and in 1944 he received the American Engineering Council's Hoover Medal for outstanding public service.

IN THE course of a recent journey to the West Coast, I was transferred through the trunk lines of four great railroad systems; the third transfer was made during the night. There was no confusion and no delay. No change from one car into another was necessary, for the rails of the lines were fortunately the same $56^{1}/_{2}$ in. apart, and their cars automatically braked and coupled with each other.

This is a remarkable circumstance in American life which all of us take entirely too much for granted. Our incandescent lamp finds the same socket in Springfield, Vt., and Springfield, Ill. The $15^{1}/_{2}$-34 shirt we sent as a present from Iowa will fit the neck and arms that grew up to size in Virginia. In Chicago we buy a tire that was made in Akron, and it will fit the wheel (made in Pittsburgh) of the car (built in Detroit) that we bought in New York.

This simplification and workable interchangeability of parts and practices is known as standardization.

The fact that we have a high degree of standardization has made life simpler for us in ways so basic and so obvious that we do not even realize they exist. It has given us the free national market which we take so casually. It has given lower prices and better quality, more safety, greater availability, prompter exchange and repair service, and all the other material advantages of mass production. Is this something to be taken for granted?

Standardization is economically and socially desirable at any time, but in time of war or preparation for war it becomes nothing less than a requisite for survival. The most eloquent plea for standardization I know was uttered in wartime. A U. S. Eighth Air Force mechanic said bitterly: "We can't borrow plane parts from the British. We can't even steal them. They don't fit."

Throughout World War II we had a higher degree of industrial standardization than any nation, including our own, had ever applied to the winning of a war. American mass production, *made possible by standardization*, was our number one weapon in that war. And yet we cannot possibly estimate the loss we suffered because of lack of certain standards. Our losses really began in the spring of 1940, when 400,000 Belgian troops might have fought better and longer if British ammunition had fitted their empty rifles. The losses continued at the first battle of El Alamein, where a contributing cause of the British defeat and retreat was the lack of standard interchangeable parts in the radio and other auxiliary equipment of the British tanks. At home we lost the services of thousands of small companies which would have participated in war production if there had been a comprehensive system of national defense standards to which they were accustomed to work.

At one moment early in the war, lack of a standard almost caused disaster on the grand scale. A part broke in one of the radar units protecting the length of the Panama Canal. Those in command were dismayed to discover no replacement part in stock. They put through a rush call to have the part flown to the Canal. Long before it arrived, however, the officer in charge of stores made a foot-by-foot search of his warehouse. He found eight full bins of the needed part, all marked with a different stock number. "Stock duplication caused by lack of or deficiency in a standard parts catalogue," standards men call it.

Very probably it was a screw thread that cost this country its greatest losses in time, money, and materials. The screw thread is a simple device, but it ties together the whole mechanical skeleton of our civilization. The British Whitworth Standard and our own American Standard

differed only slightly in their dimensions, but the difference might as well have been as wide as the Atlantic Ocean.

William L. Batt has estimated that because of lack of interchangeability in screw threads we shipped about 600 million dollars abroad in the form of extra screws, nuts, and bolts as spare parts. When Packard took over the manufacture of the Rolls-Royce Merlin engine, it had to spend ten months redrawing 2000 blueprints American fashion and translating the Whitworth thread forms.

II

How do we stand today? We are in some ways, notably in productive capacity, far ahead of where we were at the start of the last war. As far as standardization is concerned, that is remarkably true. We are much better prepared in standards today because of things learned, of men trained, of work done in standardization over the past ten years.

The Panama Canal incident, for example, started widespread reforms in the purchasing habits of the armed forces. As a direct result of it, the Army Signal Corps made a three-month analysis that eliminated 63,000 duplicate or nonstandard items out of 220,000 pieces of Signal Corps equipment. In 1945 the Navy—which had spent 55 billions during the war for the goods of industry, surveyed its 50 million stock numbers. Of the first 15 million checked, only 2 million represented parts actually in use. Because some identical parts were listed under as many as 630 different numbers, this 2 million in turn was reduced to 80,825. Today the project of simplifying and standardizing the stores of the entire military establishment is well under way.

In 1943 Britain, Canada, and the United States held the first international conference on screw thread unification. Five years and five conferences later, on November 18, 1948, these three countries agreed on a Unified Standard. That is of tremendous importance to the security of the Western world.

Whether or not we Americans appreciate standards, whether we examine them in peace or in time of war, standardization is a fundamental characteristic of our economic system. It got us where we are today. But we have cashed in on only a fraction of what peacetime standards can give us in almost any field.

House construction, one of the least standardized of our industries, is a perfect example of what standards could do if given the chance. I hasten to add, however, that I am not proposing rows of identical houses under uniform trees. Standardization is an engineering technique and it has nothing to do with unaesthetic uniformity.

Just a glance at a sash and door catalog, with its fifty or more bastard sizes of doors and windows, gives a hint of how many dollars might be saved per dwelling by an industry-wide program of simplification and workable interchangeability.

III

Standards to remedy these and other conditions do not come about by accident. They are born in a conscious effort; they are developed with organized machinery. Today the question of who is to control this machinery is a problem of our internal economy that is at once unrecognized, obscure, and crucial.

Early in the present century, the situation became involved with the growing complexities of our industrial society. The Federal Government joined producer and user as the third partner in the making of standards.

This intervention began as a means of curbing abuses, of regulating standards affecting public life, health, and safety.

Historically, the Federal Government has an admirable record in formulating standards, in supporting the principles of standardization, and in promoting their knowledge and use, particularly in the field of health and safety. Government obviously has the right to set standards for the goods it buys.

So much is granted. But there is a wide difference between "some" and "much," and an even vaster distinction between "much" and "all." I am for the spoonful of vinegar in the salad dressing, but I am against a cupful. There are trends, plans, and proposals currently under way that would make standardization wholly or mainly a function of government, and I am opposed to them. I do not want my talented, capable, and sincere friends in the Federal agencies in Washington to write the industrial standards of this country. Too much is at stake.

Standards are now built into the very structure of American industry. They are the controls that management employs to direct smooth and efficient company operation. The standards a manufacturer uses in operating his plant, the control of the quality of his product, the specifications under which he sells that product—all these are fundamental functions of business management.

If you control an industry's standards, therefore, you control that industry—lock, stock, and ledger. On the day that standards become a governmental function and responsibility, as is now being threatened, the government will take a very long step toward the control of American industry. That is a step which will reach into every manufacturing and operating company, big and little, and consequently will affect every consumer in the country.

In such a setup, government personnel will decide when and what standards should be developed and what the provisions of the standards should be. That method is inflexible.

Standards made under such conditions tend to become limitations, controls, and restrictive procedures. They reduce consumer choice. The manufacturer obeys an order he had no part in formulating.

I am opposed to government control of standards activities, however, for a much simpler reason. No government planner knows enough to write the standards for the rest of American industry and all other American people. Even if he and his advisers were as wise as Jupiter, he would still stand helpless before economic forces which are too powerful, delicate, and complex for individual control. In 1933, when such ideas did not have their current acceptance among our best thinkers, I wrote in an *Atlantic Monthly* article entitled "Business Looks at the NRA" as follows:

> "The enormous extent of our operations in manufacturing and distributing material goods, their unimaginable variety, the incalculable complexity of the courses they take, the innumerable final desires and satisfactions they reach and serve, are beyond the comprehension or calculation of any planning board."

In the words of a great modern English statesman on a totally different subject, "I was rather pleased with this when I wrote it, and I don't mind the look of it now."

IV

Now the situation certainly alters when people begin to shoot at us. In time of war we must quickly take special measures to save materials and manpower, to bring maximum efforts and resources to bear on production and mobilization. Under such pressure there are naturally tendencies and a will to give full authority to a planner or a group of planners, to hand down standards by decree. A point to remember, however, is that they must still be effective, workable standards. Those they hand down are as likely as before to be unrealistic, uncreative, and unnecessarily expensive. With this added difference: their errors can now be a thousand times more serious.

Nazi Germany practiced standards by decree and paid the price for it, notably when it standardized its military airplanes too much and too soon. Our own experience in World War II demonstrates that we worked best when industry was not only consulted in the development of the standards of the goods it was to manufacture, but also participated in decisions as to what the contents of the standards should be.

If the answer to the problem of standardization is not to be found in standards written by the manufacturer alone, or by the consumer, or by federal agencies, where then is it to be found?

It lies with no one of them, I think, and with *all* of them. The solution lies in consensus. Where everyone is affected by standards, everyone should make the standards. Every group substantially concerned—manufacturer, designer, distributer, seller, consumer, the government—should have the right to participate in deciding what the provisions of a standard shall be, and none should dominate the decision at the expense of another. For if a standard is to be of any value, it must be generally acceptable to all who use it. Industries, like people, are most willing to

abide by regulations which they set up themselves.

Voluntary standardization on the consensus principle works. The fact that it works because of the businessman's desire to stay out of trouble and make a profit is incidental. The businessman, just like every other individual, is motivated primarily by self-interest. We hope that self-interest is enlightened, but whether it is or not, if he directs his business in such a manner as to give a good economic performance and produce goods of the greatest value, then he promotes the public interest whether or not he intends it, wants it, or even knows it.

The thirty-year record demonstrates that voluntary standardization is an entirely workable and practical system. The American Society for Testing Materials, for instance, has cut across industries to write hundreds of useful voluntary national standards. The trade associations and technical societies of private American industry have written thousands of voluntary and socially beneficial standards. Many of these standards have been industry-wide and national in scope and have included varying degrees of government and consumer participation. Because they have been written under the pressure of competition, they must please the customer or flop, and they must therefore be periodically revised.

The American Standards Association was founded in 1918 by five of the country's leading engineering societies and three government departments—War, Navy, and Commerce—to bring order to the confused field of standardization. It now comprises 106 technical societies, trade associations, and groups of such organizations, and some 1800 private companies.

It works to simplify developments of engineering, commercial, consumer, and safety standards; to eliminate duplication, overlapping, and variables of standards activities by other standardization bodies in the country; to promote knowledge and use of standards; and to serve as a clearinghouse for information on all standards in the U. S. It serves as the channel of co-operation with the standards bodies of the twenty-nine other nations which belong to the International Organization for Standardization.

[NOTE FROM EDITOR.—Dr. Flanders then continues with further discussion of the ASA.]

In World War II, enforced government standards entered our private lives in ways that would have been unthinkable and, I hopefully presume, unacceptable in time of peace. The government standardized tubes for civilian radios and the thickness of leather permitted in a half sole; bicycles (twenty types reduced to two) and working clothes (six types); the number of pockets on women's coveralls (two); the style of pants' cuffs (none) and the length of your shirttail (shorter).

While these War Standards were compulsory, the consensus principle, nevertheless, was maintained to a marked degree in writing them. At the consultation table, private industry retained its position of the responsible producer and the government, with the war effort absorbing nearly half the national economy, assumed the position at once of buyer and user. When properly carried out, this procedure developed War Standards that did not unnecessarily depart from current industrial practice and made good use of the technical and creative abilities of American industry.

In its rearmament program of the past two years, the military establishment has achieved notably successful results where it has continued to follow the consensus principle in writing standards. But there is a greater danger that the government, using the war emergency as an opportunity and an excuse, will not only take over full powers in standards activities but will fail to relinquish them when the emergency ends. There is a group, both in and out of government, who feel that standardization is properly a government responsibility. In two, five, or ten years when, God willing, we begin again to take up life in a postwar economy, the cry will be louder than before that our standards should be written in the government offices.

I think that neither now nor later can we afford such a reversal of our economic and technical processes. Our standards are now basic to our industrial economy. They will be more important than ever as we organize resistance against aggressive forces. When this crisis ends, we must work to achieve a higher degree of harmony and order in our world; to relieve the strain of modern living by simplification; to increase the standard of living through more efficient production of interchangeable parts in a free market. We must use standards as "the liberator that relegates the problems that have already been solved to the field of routine, and leaves the creative faculties free for the problems that are still unsolved."

I say that this is not work for the master planner. Creative dynamic standards are not composed on the higher levels and handed down by decree and proclamation. They are formulated by the voluntary agreement of all groups concerned. They must be worked out by the people themselves.

ASTM DISTRICT ACTIVITIES

Stress Analysis at District Meeting Pittsburgh

UPWARDS of 250 members of ASTM, the Instrument Society of America, and the Society for Experimental Stress Analysis were in the auditorium of Mellon Institute when ASTM District Chairman M. D. Baker opened the joint meeting of these three organizations on Thursday, March 29. The technical feature of the meeting was a lecture-demonstration on "Stress Analysis in Action" by William T. Bean, Jr., Consulting Engineer and Director, Industrial Electronics, Inc., Detroit. This meeting was held as the last function of the ISA conference in Pittsburgh featuring a symposium on "Instrumentation for the Iron and Steel Industry." Consequently, there were quite a number of men at the joint meeting from various sections of the country.

Mr. Baker introduced J. B. McMahon, National President of the ISA; H. N. Hill, District Chairman of SESA; and ASTM Assistant Secretary R. J. Painter, each of whom spoke briefly.

Mr. Bean's lecture-demonstration was along similar lines to those he has given at other district meetings, news accounts for which have appeared in previous ASTM BULLETINS, with the exception that he brought it up to date with the latest equipment. His array of equipment spread across the Mellon Institute stage and all was in operation. He covered it thoroughly, explaining the use of the strain gage and other stress measuring instruments. He emphasized the relationship of good stress analysis, *plus* good design, *plus* good materials, *plus* good processing, if maximum efficiency is desired.

For those who are interested in further information on the general subject covered, a former paper by Mr. Bean entitled "Endurance—a Criterion of Design," is published in the ASTM Symposium on Testing of Parts and Assemblies.

Mr. Bean's lectures, given in an informal, sometimes amusing vein, are presented in a way which drives home quite forcibly the important points he emphasizes, and unquestionably every one of those in the audience felt repaid for their attendance.

The Pittsburgh District Officers—Chairman M. D. Baker, Chief Chemist, West Penn Power Co.; Vice-Chairman F. T. Mavis, Head, Dept. of Civil Engineering, Carnegie Institute of Technology; and Secretary H. F. Hebley, Director of Research, Pittsburgh Consolidation Coal Co., handled in excellent fashion arrangements for the meeting in cooperation with the two other groups.

Members in Southwest Greet Executive Secretary

Interesting Meetings in Dallas, Houston, and Birmingham

Continuing the account in the April Bulletin of the visit of President Markwardt and Secretary Warwick with Pacific Coast members in Portland, San Francisco, and Seattle, there follow some notes on visits of the Secretary with members in Dallas, Houston, and Birmingham on the homeward swing.

Dallas:

A dinner meeting with a group of about 15 members was held Thursday evening, March 22, at which Edwin Joyce, Division of Production, American Petroleum Institute, presided. The Secretary spoke informally on various current activities in ASTM, followed by a spirited and interesting discussion in which everyone participated.

During the two-day stay in Dallas, the Secretary visited the offices of the Production Division of the American Petroleum Institute; the Research Laboratories of the Atlantic Refining Co. (Crude Oil Production Division) where he was the guest of the Director of the Laboratories, L. P. Whorton, and J. H. Sullivan, Senior Laboratory Engineer; the Civil Engineering Department of Southern Methodist University where he met the head of that Department, Prof. Sophus Thompson, and Prof. A. C. Willis; and the Chance Vought Aircraft Plant where he was the guest of David G. Reid, Vice-Chairman of ASTM Committee C-19 on Structural Sandwich Constructions. Other contacts included F. B. Porter, President of Southwestern Laboratories, Fort Worth; L. H. Stern, Pittsburgh Testing Laboratory; Sidney Lee, Dallas Laboratories; E. F. Schmidt, Lone Star Gas Co., Vice-Chairman of ASTM Committee D-3 on Gaseous Fuels; Carl V. Peterson, Greene Brothers, Inc., laboratory supply house; H. N. Cedergren, Metallurgical Engineer and Owner, Cedergren Metals Co.; and C. A. C. Faiman, Jr., National Metal and Smelting Co., Fort Worth.

Houston:

Three days were spent in Houston—barely time to glimpse a picture of the tremendous industrial development of the Houston-Texas City-Galveston area, and to visit with some of our members. A dinner meeting was held on Tuesday, March 27, attended by some 20 members and guests at which, as at Dallas, very interesting discussion of Society work followed informal remarks by the Secretary. H. M. Shilstone, Jr., of Shilstone Testing Laboratory presided at the dinner which was sponsored by Mr. Shilstone and three other members, namely, W. H. Curtin, President, W. H. Curtin and Co., Inc., laboratory supplies; Roy E. Hall, Works Manager, Wyatt Metal and Boiler Works; and M. T. Works, Chief Engineer, Cameron Iron Works, Inc. Of the three days spent in Houston the better part of one day was devoted to a tour of the industrial area surrounding the Houston Ship Channel, arranged by C. S. Wilson, Engineer of Tests, Texas and New Orleans Railroad Co. This included a visit to R. W. Schlumpf, Chief Metallurgist, Hughes Tool Co. The second day was devoted to visits to the offices of W. H. Curtin and Co., Inc., Pittsburgh Testing Laboratory, and a trip to Galveston and Texas City where the Secretary met H. E. Morris, Director of Research and Control Laboratory of Monsanto Chemical Co., and the company's Librarian, Miss Effie Birdwell, who represents the Monsanto membership there. The third day was devoted to visits to the Shilstone Testing Laboratory; the plants of the Wyatt Metal and Boiler Works, and the Cameron Iron Works—both long-time members of ASTM; Prof. L. B. Ryan, Head, Civil Engineering, Rice Institute; and J. B. Baird, Manager of the Houston Office of Southwestern Laboratories.

Other members whom the Secretary met were: H. E. Bovay, Jr., Consulting Engineer; A. B. Campbell, Executive Secretary, National Association of Corrosion Engineers; B. B. Manuel, Curtin & Co.; A. J. Dawson, Consulting Engineer; A. V. Meigs, Uvalde Rock Asphalt Co.; Frank H. Newman, Jr.; Thomas C. Tweedie; R. H. Price, Pan American Refining Corp.; W. B. Brooks, Dow Chemical Co.; and L. S. Wrightsman, P. L. De Verter, and J. F. Hickerson, Humble Oil and Refining Co.

Birmingham:

A brief visit to Birmingham included a dinner meeting on Thursday, March 29, of some 15 members of the Society presided over by J. R. Trimble, Assistant Manager, Department of Metallurgy, Inspection and Research, Tennessee Coal, Iron and Railroad Co., and a Director of the Society. Present at the meeting were two former directors of the Society, J. T. MacKenzie, Technical Director, American Cast Iron Pipe Co., and Oscar U. Cook, recently retired from Tennessee Coal, Iron and Railroad Co. Others present included C. K. Donoho and R. E. Deas of Acipco; T. C. Bradford, Southern Testing Laboratories, Inc.; R. W. Mooty of Teirr; R. B. Coleman, Jr., and E. A. Bartlett, Southern Cement Co.; W. B. Lame and H. Grandberry, West Point Manufacturing Co., Shawmut, Ala.; Harry Majors, Jr., Director, Engineering Experiment Station, University of Alabama and Miss Henrietta Thompson, also of the University of Alabama, Tuscaloosa; and Martin De Fore, Cement Reference Laboratory, National Bureau of Standards. Miss Thompson gave an interesting description of work in the Department of Clothing and Textiles which she heads at the University, with particular reference to graduate and research work in the field of ultimate consumer goods. There was a discussion of certain phases of ASTM work of interest to those present.

The Secretary visited the Southern Research Institute and met various members of its staff. Dr. W. M. Murray, Jr., Director of the Institute, is a member of the Society. Brief trips to

Joint Meeting of the Northern California District ASTM and Structural Engrs. Assn. of Northern California. President L. J. Markwardt; John E. Rinne, President of Structural Engrs. Assn. of Northern California; L. A. O'Leary, Chairman Northern California District Council; Executive Secretary C. L. Warwick.

Left to right: John T. Young, Los Angeles Bureau of Standards (ASTM District Councilor); C. M. Wakeman, Los Angeles Harbor Dept. (Chairman, ASTM District); Frank Galloway, Bureau of Standards; Myron Niesley, California Testing Laboratories (Secretary, ASTM District); ASTM President L. J. Markwardt, U. S. Forest Products Laboratory; William Barr (Past-President, ASTM, 1940–1941); Executive Secretary C. L. Warwick. (Mr. Warwick is probably squinting because he's not accustomed to bright California sunshine, although Philadelphia has done better since the photograph was taken.)

certain plants of the American Cast Iron Pipe Co. and Tennessee Coal, Iron and Railroad Co. completed the visit to Birmingham.

One cannot help but be greatly impressed with the industrial developments in each of these three localities, especially those in the Houston area which have so greatly expanded in the last decade. The opportunities for extension of ASTM membership in all three centers are considerable, and the Executive Secretary was gratified both by the cordial reception accorded him and the assurance of the members in these areas of their desire to help in every way in building up ASTM membership and influence.

Dr. H. H. Uhlig on "Corrosion" at Hartford Meeting

(140 Hear Excellent Talk)

AN EXCELLENT talk on "Corrosion and Its Effect on the Properties of Metals" by Dr. Herbert H. Uhlig, Professor of Metallurgy at Massachusetts Institute of Technology, an outstanding authority in this field, was followed by a question and answer period of almost three quarters of an hour at the first ASTM meeting to be sponsored in Hartford. The New England District, particularly its active Council, is to be complimented on this fine meeting. The team of Lester-Gramstorff-Lutts-Chadbourn-Woodward-Bly, with the help of another cooperating contingent, Shields-Voss, planned and carried the meeting through. Mr. Chadbourn headed the District Program Committee, and with the close cooperation and intensive help of the Hartford group headed by R. W. Woodward, with J. H. Bly and other Hartford members cooperating closely, one of the best District meetings of the year resulted.

The Hartford group had done a very effective promotional job, inviting a number of chapters and sections of other societies in the area, but there was an excellent turnout of ASTM people also. The Council held a business meeting at the Pratt & Whitney plant in the afternoon, and a Cocktail Party preceded the excellent buffet supper at the Hartford Canoe Club.

District Chairman, H. H. Lester, introduced various men, including Assistant Secretary R. J. Painter, who extended greetings, described briefly the ASTM District setup, and noted some of the intensive and long-time ASTM work in the field of exposure tests particularly. He mentioned the work of the Coordinating Committee on Corrosion and its plans for raising about $100,000 to advance more effectively the corrosion work through procuring more extensive test sites on a long-time basis, and other suitable facilities.

Dr. Uhlig, who was introduced by Mr. Woodward, has worked in the field of corrosion since 1936, when he was in charge of the M.I.T. Corrosion Laboratory, later had considerable industrial experience—for example, with General Electric Co., and in 1946 returned to M.I.T., where he is now Professor of Metallurgy and in charge of the Corrosion Laboratory.

He first brought home vividly to the group some of the ravages and economic losses from corrosion. For example, there are some 30,000,000 domestic hot water heaters in operation in this country, and with an average replacement per year of 10 per cent, which is considered conservative, the replacement cost would run over $200,000,000. Somewhat facetiously but nevertheless impressively, he mentioned that corrosion from the standpoint of some managements may not be recognized. One manager, for example, when asked how often he had to replace a pump circulating a very corrosive fluid, replied: "Oh, about every six weeks." It was demonstrated that with certain types of protection the pump could be made to last ten times that long, showing management how they could attack this corrosion problem.

The speaker then noted the basic types of corrosion, such as allover surface attack, internal reactions, for example intergranular corrosion, stress corrosion cracking, and corrosion fatigue. He gave illustrations of each.

Finally, he described very briefly methods of protection, for example, surface coverings, cathodic protection, and others, and then gave specific examples of cathodic protection, for example in pipe lines and immersed metals.

As noted, there was a flurry of questions following his talk. The entire audience was greatly interested in his specific and constructive replies.

It was patent that the problem of corrosion, including inhibiting or retarding it, is of interest to all engineers, and that it would unquestionably be worthwhile for the engineering student to have corrosion studies on his roster. In this connection, it was announced that M.I.T. is having an intensive full-week seminar on this subject, early in June, designed to be of interest to industrial engineers and technologists.

From the start of this meeting, which was the Council business session, to the final motion for a vote of appreciation, the events went off successfully, demonstrating how careful planning can insure the success of a District meeting.

For further information in regard to the summer corrosion course at Massachusetts Institute of Technology write to Walter H. Gale, Director of Summer Session, Room 3-107, MIT, Cambridge 39, Mass.

New York Meeting. A news account of the successful New York District Meeting featuring technical papers on synthetic fibers will appear in the July BULLETIN. There was an attendance of over 200 at this session held on April 20. Consideration is being given to publishing extended abstracts of the papers or printing in full. See the July BULLETIN for details.

"Metallurgical Development" as Applied to High-Temperature Structural Service

THE April BULLETIN noted that a paper on "Metallurgical Development" was delivered by W. A. Reich, Head, Metallurgical Section, Schenectady Works Laboratory, General Electric Co., at the Philadelphia District Meeting, February 20, 1951. This meeting was planned to present examples of the problem with which most technical and research men are faced from day to day of planning, procuring, evaluating, and using data. Mr. Reich chose to cover this subject with specific examples from the metallurgical field. The interest with which this paper was received and the timeliness prompted this résumé which follows:

The author first stated that advances in efficiency of power plants made over the past years have been made possible to a large degree through the development of better high-temperature alloys.

In developing an improved alloy, the first consideration in analyzing properties is given to strength. Thus a turbine wheel must not flow or creep excessively when subjected to high centrifugal stress and temperature. Disablement of the unit would be caused if there is insufficient clearance between buckets and casing. As another example, the author pointed out that "a pipe carrying high-pressure steam may enlarge perceptibly without serious consequences, but its rupture strength must be high enough to allow safe operation for many years."

Other characteristics must be considered such as damping capacity, since an alloy without the ability to absorb vibrational energy may upon application of vibratory load allow the build-up of large amplitudes of vibration resulting in subsequent failure.

Corrosion resistance is an important property to be considered—for example, resistance to the products of combustion such as fuel ash. Thermal shock resistance, a complex summation of several other physical properties such as thermal conductivity, thermal expansivity, and perhaps rupture strength, is of great importance since there may be a sudden local concentration of heat input as in a gas turbine diaphragm partition or combustion chamber. Metallurgical stability of the material is always desired—for example resistance to graphitization.

All these properties have to be considered when high-temperature alloys are developed, but in addition, it is necessary to solve problems which are related to the ease of fabricating the material. Attention must be paid to characteristics like machinability, weldability, hot workability, notch ductility, etc. Processing instructions for this reason present a best compromise between desired properties for service and those needed successfully to make something useful out of the material considered.

The author then clarified the use of the term "designing" the material. This term is used to focus attention on the progress that has been made in realizing one of the most cherished dreams of the research or development metallurgist—that of being equipped with enough general principles based on sound experimental grounds to allow him quickly to derive a needed new material and proper manufacturing procedure without resorting to costly "shotgun" experimentation.

Mr Reich described a few of the relationships between the high-temperature properties of materials and their composition, heat treatment, etc., available to the metallurgist. Thus it is realized that the highest melting metals show the greatest high-temperature creep and rupture strength. On the other hand, metals and alloys have also been found to be weak when they are near or in the temperature range where crystal structure changes occur. Recognition is thus given to the fact that an alloying element which raises the melting point of the base metal or alloy, or raises the lower end of the temperature range in which crystal structure takes place, should be beneficial in raising its useful service temperature.

Grain size and its effect on creep and rupture strength was next discussed. Mr. Reich noted that "for a given material a fine grain size produces highest long-time creep and rupture strength at low temperature and lowest strength at high temperature." The problem naturally is to determine the temperature above which large grain size pays off, and it was determined that the common ferritic high-temperature alloys should be coarse-grained above 1000 F. for maximum temperature creep and rupture strength. This is, as the lecturer pointed out, partly responsible for the controversial "No Aluminum" clauses appearing in some high-temperature alloy specification.

Effect of grain size on fatigue strength seems quite different. Most available data support the preference for a fine-grained material where maximum resistance to rapidly oscillating stress at elevated temperature is desired.

Furthermore, the author pointed out that microstructure and its effect on creep and rupture strength at elevated temperatures have also received a lot of attention. The best structure for high creep and rupture strength for low-alloy steels at an elevated temperature appears from recent work to be produced by isothermal transformation at this temperature.

The use of precipitation hardening is of extreme importance to the development of high-temperature structural alloys. In fact, most of the bucket alloys for jet engines rely on this phenomena whereby certain alloying elements are dissolved in the matrix by a high-temperature "solution treatment" and are then caused to combine and precipitate in strategic distribution during the so-called "aging treatment," thus forming a "structure" resistant to deformation under stress at elevated temperature.

Effect of composition on the high-temperature properties of iron-base alloys was covered. Molybdenum is most effective in improving creep and rupture strength of low-alloy ferritic steels and high-alloy austenitic steels, while chromium, nickel, silicon, and cobalt have little effect on the high-temperature strength of iron. Vanadium and titanium increase the high-temperature strength of ferrite; columbium is perhaps the most effective element, but the critical nature of its supply limits its use to the most important application.

In carbon steels, carbon is a strengthener at elevated temperatures; but in low-alloy steels of the chromium-molybdenum or chromium-molybdenum-vanadium type the effect is not pronounced.

Mr. Reich then gave a short account on research carried out at his own company, where approximately 2000 alloys were melted in a study of the system involving iron, chromium, nickel, cobalt, tungsten, and molybdenum. Pure alloys by a special vacuum melting process were produced to obtain data which would be helpful in setting up methods for formulating high-temperature alloys.

Damping capacity, oxidation resistance, corrosion resistance and graphitization were mentioned. The hardenable 12 per cent chromium alloy used so widely for steam turbine buckets has a remarkably high damping capacity.

Oxidation resistance becomes important as service temperatures rise and the long recognized effectiveness of chromium is made use of by its addition in moderate amounts to ferritic materials and to the extent of about 20 per cent by weight in most so-called super-alloys for gas turbine service temperatures.

The author suggested that the answer to the fuel oil ash corrosion problem will ultimately lie in inhibiting additions

made to the fuel itself, and much effort is presently being applied to this approach.

Graphitization may not be entirely understood as to mechanism, but concentrated effort has given enough information to steer around this difficulty, and it now appears that the addition of about 1 per cent of chromium to a low-carbon ferritic alloy will allow one to leave this problem and devote oneself to other important matters.

Such things as hardenability and notch ductility at room temperature and below are important to the manufacturer and fabricator. The welder likes the hardenability and the carbon content to be low, and in addition to those properties the material should behave in a ductile fashion when subjected to rather complex stress systems.

Next Mr. Reich discussed some of the methods used by the metallurgist in his search for high-temperature alloys. The test method most important is the creep test since the discovery that strain or creep occurred as a function of time under stress at elevated temperature first focused attention on the need for more than the conventional room-temperature or short-time elevated temperature mechanical test data for use in design. Next to be considered using the same test procedures as for creep testing was the rupture test. The amount of time consumed in obtaining creep and rupture data varies according to the type of application for which the data are desired. For instance, high-temperature tests of only a few minutes duration can yield useful data for rocket applications.

Fatigue testing of high-temperature alloys was discussed. In connection with fatigue test data, one thing had to be considered, "that the occurrence of a so-called endurance limit or apparent asymptotic value of stress on the stress *versus* log life plot may disappear at elevated temperatures, and one must speak of fatigue life prefacing the fatigue strength with proper number of cycles to failure." Properties such as graphitization resistance and oxidation resistance are obtained by exposure tests.

The lecturer continued to discuss test procedures and how important it is to simulate actual operational conditions in these tests. He mentioned, for example, that the thin edge of the airfoil section of a cast gas turbine bucket may contain columnar grains with their axes perpendicular to the edge in the blade casting and to discover this phenomenon may require operational tests whereas tests on test specimen may not exhibit this particular combination of structure and stress concentration. This is one reason why many fatigue tests are conducted on the actual object and not on a test specimen. Another example of the need for determining service behavior is encountered with the composite gas turbine wheel where an austenitic rim is welded to a ferritic steel hub.

As his next step, Mr. Reich described an example of a typical alloy development. It had been found that the addition of 1 per cent molybdenum to a low carbon steel gives most of the strengthening effect which can be obtained with this element without making the material unresponsive to heat treatment. It had also been found that 0.15 per cent of vanadium insured a precipitation hardening steel. Since carbon in excess of 0.15 per cent had little effect on the high-temperature strength, this element was limited to 0.20 per cent maximum. Thus the first vanadium-containing piping steel had a nominal composition of 1 per cent molybdenum, 0.2 per cent vanadium, and carbon content between 0.10 and 0.20 per cent. Before this steel could be purchased in the form of a pipe, a compromise on the method of deoxidation had to be found since a small amount of aluminum was necessary to assure sound billets for piercing. Aluminum deoxidation was limited to ½ lb. maximum per ton. To obtain a substantial precipitation-hardening effect in such steels, a solution treatment on the order of 1050 C. followed by rapid cooling was necessary. Some of the piping so manufactured showed cracks through the walls. Upon extensive testing of the defective pipe involved, it was decided upon to anneal the material immediately after hot rolling and prior to the cold straightening operation. One per cent chromium was also added to insure freedom from graphitization.

In conclusion, Mr. Reich again emphasized three points:

1. The science of metallurgy may not be developed to a remarkable degree of exactitude as yet; however, one must be impressed by the strides that have been made even in the relatively restricted field of high-temperature metallurgy.

2. The development of a high-temperature structural material and its processing cannot be successful without taking into account the practical problems of manufacture and fabrication of the material in question and limitations imposed by presently available production equipment.

3. Despite the fact that compromises can be made between the so-called practical limitations of present-day production and the metallurgical ideal, it is increasingly apparent that further advances in the development of high-temperature structural materials, will require more and more creative thought and effort applied to production processing and equipment and some sacrifice in the properties that make production easy.

What it Takes to Drill an Oil Well

The March, 1951, issue of "The Lamp," a publication of the Standard Oil Company of New Jersey, featured on its back cover an interesting colorful outline of what it takes to drill an oil well. Since the nation's growing defense machine is demanding more and more crude oil and natural gas, oilmen are required to drill more wells than ever before. In 1950 they broke all records by completing an estimated 43,000 wells. The table below shows what is required to drill a modern oil well. It is based on figures averaged for all wells drilled in Texas during 1949. The table applies to an oil well 5840 ft deep being completed in 39.8 days and costing $77,845.

Equipment and Supplies	
Dragline	1
Bulldozer	1
Hauling and lifting trucks	14
Special service trucks	6
Well servicing truck	1
Bulk cement truck	1
Cementing truck	1
Passenger cars	6
Drill pipe	6500 feet
Conductor casing	200 feet
Surface casing	1500 feet
Tubing	5840 feet
String casing	5840 feet
Power drilling rig	1
Drill bits	4 to 50
Water	19,900 barrels
Butane	23,880 gallons
Cement	35 tons
Chemicals for mud	3.5 tons
Drilling clay	15 tons
Weighting material	45 tons

Men	
Workmen	16
Truck drivers, helpers	10
Rig builders	5
Tool pusher	1
Rotary drillers	4
Rotary helpers	17
Geologist	1
Surveyors	4
Petroleum engineer	1
Electric logging crew	2
Drill stem testing crew	1
Sidewall coring crew	2
Casing perforation crew	2
Caliper logging crew	2
Gamma ray logging crew	2
Mud logging crew	3
Cementing crew	3
Total	76

ASTM TECHNICAL COMMITTEE NOTES

Activity of Committee C-2 on Magnesium Oxychloride and Oxysulfate Cements

THE major business at a meeting of Committee C-2 held April 27 in Washington, D. C., was consideration of three proposed specifications which were accepted for recommendation to the Society. Covering magnesia, magnesium chloride, and magnesium sulfate, they represent the initial efforts of the committee in the writing of specifications.

During the past year, 17 methods of test have been accepted as ASTM tentatives, thus giving sufficient reference information for the writing of specifications. Three of the methods now appearing as ASTM tentatives were recommended for advancement to standard. These cover Sampling Magnesium Oxychloride Compositions and Ingredients (C 237 T), Sieve Analysis of Magnesium Oxychloride Compositions, Aggregated and Fillers (C 238 T), and Sieve Analysis of Plastic Calcined Magnesia (C 239 T).

A method for measuring shear in testing bonding mediums will need to be developed in order to have a complete set of test methods for evaluating oxychloride cements.

The need for a list of definitions of terms pertaining to the various tentatives adopted, as well as terms common to the industry, was expressed, and a task group will initiate this activity. The subject of durability or soundness of oxychloride cements was discussed. It was pointed out that considerable data are available on short-term performance, but there is need for information on long-term behavior of these cements. Consideration, by the committee, of test methods to evaluate conductive flooring material, is being held in abeyance, pending the findings of the National Fire Protection Association.

Progress Continuing on Exposure Test Sites Program

THE Advisory Committee on Corrosion, organized in 1942 primarily to effect simplification of the ASTM exposure test site situation, held its most recent meeting in March in New York City. The results of intensive work under way indicate that considerable progress has been made by the committee in establishing a number of test sites which have reasonably long and secure tenure and have adequate size and relative freedom from possible later encroachment. A number of these sites have been equipped with new pipe frames and specimen racks, and additions to original sites have been increased and fenced in.

The original cost of the acquisition, supervision, and maintenance of such sites over a ten-year period was estimated to be at least $100,000. The response to a general appeal for funds has been quite gratifying, and as of April 13, $79,650 had been pledged to the ASTM exposure test site fund. Names of contributors were listed in the January and February BULLETINS. The following organizations are those not included in the two previous lists.

Atlantic Refining Co.
Babcock & Wilcox Co.
Colorado Fuel and Iron Corp.
Duquesne Light Co.
General Motors Corp.
Lloyd's Register of Shipping
Manning, Maxwell and Moore, Inc.
Plaskon Division, Libbey Owens Ford
Sears, Roebuck, and Co.
Shell Development Co.
Sylvania Electric Products
Tennessee Eastman Corp.

Another general appeal for funds will be made, probably some time in June, in an effort to reach the desired goal.

Notes on Test Sites:

Sandy Hook Although it is more than a year since the ACC was advised that the Army was abandoning Fort Hancock and the land would be taken over by the State of New Jersey as a state park, no further developments have taken place other than that the Army has left. The test site is still located in an area, access to which is protected by civilian guards. The Army has further advised that the property is being rescreened against the needs of other Federal agencies in view of the national emergency.

Pittsburgh, Pa. Brunot Island test site established some 25 years ago was abandoned after the spring inspection by Committee A-5. Several racks of wire specimens were removed and placed on the roof of one of the Bureau of Mines buildings.

South Florida It was agreed that for the present the Society will continue to use the test site at Key West rather than establish an entirely new site in the South Florida area.

Panama Canal Zone The consideration of a test site on Barro Colorado Island on Gatun Lake in the Panama Canal Zone had been discontinued as it is felt that the area available is not as severely tropical as is desired. Of course the mildly tropical sites which are in use will be continued. Investigations are also being continued into a suitable severe or typically tropic area.

Columbus, Ohio The test site at Columbus established approximately a year ago through the courtesy of Battelle Memorial Inst. has been prepared for exposure by the recent construction of three 60-ft. pipe frames.

New York City There are now five 60-ft. pipe frames and approximately one

Fig. 1.—Group Making Final Committee A-5 Inspection of Brunot Island Test Site. In the usual order, H. F. Hormann (Consolidated Edison Company of New York, Inc.), Secretary of Committee A-5; E. S. Taylerson (U. S. Steel Co.), Chairman of Subcommittee XIV on Sheet Tests; W. L. Holshouser, Jr. (National Bureau of Standards); A. P. Jahn (Bell Telephone Laboratories, Inc.), Chairman of Subcommittee XV on Wire Tests; and E. W. Gardiner, (Chief Engineer, Duquesne Light Co.).

dozen racks (each capable of holding seventy 4 by 6-in. specimens) available.

Point Reyes Work is in progress at Point Reyes which is to include the fencing in of the ASTM test site area, the installation of concrete footings for a total of ten pipe frame structures, two of which are to be completed under the present contract.

Gulf Coast Consideration is still being given to the Port Aransas area, and particularly in view of the high cost of construction and erection of a 30 by 60-ft platform 14 ft above average mean water level necessary to avoid damage from periodical flood tides. Final consideration of this installation would depend upon the interest of the ACC membership.

State College, Pa. The area of the State College site has been recently increased by approximately 10,000 sq ft. This additional area has been fenced in and additional facilities have been made available.

Another thing being considered by the committee is the possibility of installing various weather instruments such as pyrheliometers at the various sites. Further consideration will be given to this matter pending the apparent interest or need by such interests as the plastics, paint, and adhesives people.

Committee C-18, Natural Building Stones

A PROPOSED specification for roofing slate was discussed at the meeting of Committee C-18 on Natural Building Stones, held on March 23 at the National Bureau of Standards, Washington, D. C. This specification covers natural slate shingles, as commonly used on sloping roofs, and also square or rectangular tiles for flat roof coverings. Three grades are contemplated, based on service periods running from 20 to 100 years, with requirements for modulus of rupture across the grain and maximum absorption limits. Action to present this new specification to the Society was postponed, however, pending the collection of further data from round-robin tests, in order to confirm the limits which have been set. Action on another proposed specification for exterior marble was also held up for a period of six months, pending further data on research being conducted by the National Association of Marble Producers.

The need for definitions was discussed, especially terms to describe grain size, texture, color, finish, polish, and hone. A standard method is needed to measure and classify grain size, and the use of photographs was proposed for study.

The findings to data on the behavior of various building stones and mortars in the exposure test wall at the National Bureau of Standards were outlined by D. W. Kessler. This test wall contains building stones from forty-seven states and sixteen foreign countries and includes granite, slate, marble, limestone, and sandstone with two types of mortar, namely, portland cement and lime. The problems under study consist of the effect of weathering, physical properties of stone setting mortars, relation of discolorations to type of mortar, watertightness of joints, durability of mortars, structural movements, and other interesting data concerning joints. This project is a cooperative research initiated by the National Bureau of Standard and the Society.

Exposure Test Wall

Committee D-10 Discusses Shipping Containers

IT WAS natural to expect that at the Spring Meeting of Committee D-10 on Shipping Containers the center of interest should be on the correlation of the experiences gained with performance standards. The committee held a two-day meeting on April 16 and 17 at the Hotel Claridge, Atlantic City, N. J., in conjunction with the National Packaging Exposition of the American Management Assn. The standard tests developed by this committee are intended to evaluate the performance of containers. Now the group is busily engaged in correlating data on the several test procedures. For example, a report was presented on round-robin testing conducted on the revolving drum test (D 782), indicating poor correlation between different laboratories as well as those conducted in an individual laboratory. Preliminary plans have been made for round-robin tests on the drop test (D 997), using metal cans in corrugated containers. A task group was organized to do similar round-robin testing on the conbur or incline-impact test (D 880).

The Subcommittee on Performance Standards discussed hazards of shipping. A review was presented of a survey being conducted by the New York State College of Forestry, and similar surveys are under way at the University of Florida and at the Fort Belvoir Research and Development Center, Corps of Engineers. A study on shock was also outlined, based on the packaged product. This includes the use of existing ASTM methods including the conbur, compression, drop, and vibration tests. It was agreed that the work of the subcommittee in the development of an ASTM performance standard would use as a basis the weight classifications and types of shipments which had previously been accepted and not the type of contents of shipping containers. Initially, it is expected that all types of commodities would be considered except those of the

category covered by the Bureau of Explosives.

A proposed method of testing pallets has been completed and is in the course of being approved. It will include a series of five tests, namely static load capacity, shock load capacity, drop test, incline-impact test, and vibration test. Progress was reported on the development of a snag test for bags, with apparatus being devised, but at present there has been insufficient data collected to formulate the test procedure.

The Subcommittee on Interior Packing, having completed its work on nomenclature, is now studying such subjects as shock absorption. It is expected to develop requirements for interior packaging and finish protection of the objects shipped, whereby a method for determining relative finish protecting quality of interior packing and cushioning materials will be studied. Initially, the problems will be outlined with a listing of biographies and of instruments now available.

At the conclusion of the main meeting, Dr. Julien H. Toulouse, Owens-Illinois Glass Co., an active member of the committee, gave a talk on "A Statistical Inquiry Into Bursting Strength Testing."

Committee D-12, on Soaps and Other Detergents Considers Standards and Sponsors Technical Papers

THE regular spring meeting of Committee D-12 on Soaps and Other Detergents, held in New York City on March 19 and 20, was featured by one of the largest attendances on record, with several actions on standard tests and definitions, and presentation of technical papers by leading authorities on problems of concern to the committee.

F. W. Smither, Chemist (Retired), National Bureau of Standards, who has been very active in the work of the committee and a past-chairman, was elected Honorary Chairman in recognition of his outstanding services.

Standardization Activities:

Two test methods which had been published as information and comment were approved by the committee for reference to the Society as tentative. These covered Test Foaming Properties of Surface Active Agents and the Determination of pH of Aqueous Solutions of Soaps and Detergents.

An important responsibility of the committee is the development of standardized terms and definitions. An agreement was reached on definitions covering *lather, foam, suds, rinse, emulsion, emulsion cleaner,* and *biphase metal cleaner.*

So that the methods studied in the committee may receive the benefit of comment and constructive criticism, Committee D-12 sometimes follows the practice of having proposed test published as information before agreeing that they receive the ASTM stamp of approval as tentative. In this category are three proposed methods covering: (*a*) Test for Surface and Interfacial Tension of Solutions of Surface Active Agents; (*b*) Rinsing for Metal Cleaning; and (*c*) Test for Buffering Action.

Among projects currently under way in the committee are methods for determining water-soluble matter, borax, and copper in soaps.

Tentatively proposed as new committee work is the investigation of test methods or specifications for sodium tripolyphosphate and sodium orthosilicate, satisfactory wetting tests, corrosion tests for washing machine components, and a suggested outline for laboratory evaluation of metal cleaners.

Technical Papers:

Under the auspices of Subcommittee T-5 on Physical Testing, a symposium on "Wetting Out Tests" was presented by Dr. Carl Draves, Leonard Shapiro, O. M. Morgan, and Dr. H. B. Walker, respectively, on "The Draves Wetting Test Method," "The Tape Wetting Test Method," "The Canvas Disk Wetting Test Method," and "The Hydrometer Wetting Test Method."

Formal papers presented at the various subcommittee meetings or at the general business meeting included:

1. An In-vivo Method for Determining the Degermining Powers of Soap Containing Hexachlorophene—Dr. Cade
2. Practical Soiled Test Piece Evaluation—R. B. Mitchell
3. A Method for Measuring the Adsorption of Anion-Active Agents on Materials Commonly Washed—W. A. Fessler
4. The Mechanical Effect Produced in Launderometer Jars—O. C. Bacon
5. A Study of the Wetting of Textile Materials—Irving Gruntfest
6. A Laboratory Performance Test for Detergents Used in Continuous Scouring of Raw Wool—E. A. Leonard
7. Function of Soaps and Detergents in Dry Cleaning—G. P. Fulton
8. The Use of Radioactive Tracers in the Evaluation of Metal Cleaners—J. W. Hensley and H. R. Suter

Since other associations are interested in detergent problems and are attacking them from various angles, reports were given by Dr. H. W. Stiegler and Emil Vitalis for the American Association of Textile Chemists and Colorists, Dr. Perry Bartlett for the Chemical Specialties Manufacturers Assn., Mr. George Fulton of the National Institute of Cleaning and Dyeing, and Mr. H. G. Suter for the National Security Industrial Assn.

Activity in Committee D-14 on Adhesives

IN ATTENDING a meeting of Committee D-14 on Adhesives, one is impressed with the variety of factors involved in the successful performance of adhesives. The committee met on April 23 and 24 at the National Bureau of Standards, with good attendance at all subcommittee meetings. A closing feature of the two-day meeting was a talk by Dr. J. J. Bikerman, Merck and Co., on fundamental factors controlling adhesive bond strength.

Continued progress on strength test methods was in evidence with revisions of existing methods being accepted, including the Tentative Test for Impact Strength of Adhesives (D 950 T). The Tentative Test for Strength Properties of Metal-to-Metal Adhesives in Shear by Tension Loading (D 1002 T) is to remain tentative, pending further review of suggested changes on length of overlap. A similar type of test to cover plastic-to-plastic adhesives is now being developed. A new test for tensile properties of cold-setting wood adhesives has been prepared. The Tentative Test for Cleavage Strength of Metal-to-Metal Adhesives (D 1062 T) is now recommended for advancement to standard without change. It was agreed to write proposed methods to measure creep and cold flow properties of adhesives, with consideration being given to both thermal-plastic and thermal-setting types.

In considering analytical test methods, discussion centered on the formulation of one or more methods for determining solids content of urea adhesives. The present procedures appearing in the Methods of Testing Varnishes Used for Electrical Insulation (D 115 T) were considered to be adaptable for use with possible variations.

Cyclic exposure test methods are in varying stages of development, the first method covering wood-to-wood adhesives is now under consideration by ASTM for approval. Two additional test procedures, covering metal-to-metal and plastic-to-plastic adhesives, are now being developed. It is expected that several methods will be prepared on the effect of biological factors on permanence of adhesives. Revisions in the Method of Test for Resistance of Adhesive Bonds to Chemical Reagents (D 896 T) will be recommended to the Society.

In the field of working qualities, the two methods covering the determination of applied weight for unit area of dried adhesive solids and liquid adhesive, respectively (D 898 T and D 899 T) were recommended for advancement to standard without change. Two methods to measure such working qualities as blocking and rate of strength development were accepted for letter ballot. Progress was reported on a method for measuring tack.

The difficult problem of writing specifications is receiving increased attention and the subcommittee having this responsibility reported on several developments. Two specifications covering general mending and label adhesives have been prepared for circulation to the subcommittee. A newly organized section, charged with the writing of a specification on wood adhesives, has outlined its approach to the problem, which will be, to write a specification to meet the most severe service conditions without specifying types. Renewed interest was expressed in conducting a further round-robin series of tests to establish additional data for the preparation of a specification on adhesives for acoustical purposes. There was some concern over the lack of response received from consumers on the need for specifications on packaging adhesives. It was the consensus that there was a need for such specifications and that it would be feasible to proceed in the drafting of such, with the first effort to be in the field of cartons of the cookie package type.

In the development of methods for measuring electrical properties of adhesives, the initial effort will be to draft an over-all test method incorporating dielectric strength, dielectric constant, insulation resistance, and arc resistance. This proposed method will be circulated for subcommittee comment.

E-3 Committee Members on Steel Analysis Panel

IN A round-table discussion on the problems encountered in the determination of nitrogen and sulfur in steel held at the 119th National Meeting American Chemical Society, Division of Analytical Chemistry, three members of Committee E-3, Chemical Analysis of Metals, were active participants. H. F. Beeghly, Jones and Laughlin Steel Corp., moderator of the discussion, stressed that the right and only method of determination will be that which best meets the requirements of the analyst. J. J. Furey, Carbide and Carbon Corp. reported that in the analysis of low-carbon, ferrochrome steels the use of frequent blank determinations made nitrogen-free water unnecessary. These blank determinations are meaningless if the reagents are not checked frequently against standard samples. The third member of the nitrogen panel J. L. Hague, National Bureau of Standards, stated that a semimicro procedure has been worked out, being the most suitable for the wide variety of materials to be analyzed.

Scientific Apparatus Makers Association Has Active Meeting; ASTM Members Honored

AT THE annual meeting of the Scientific Apparatus Makers Assn., White Sulphur Springs, April 15–18, three companies which are celebrating their 100-year anniversaries this year received certificates in the SAMA Century Club. These three companies, all affiliated with ASTM also, are Corning Glass Works, Eimer & Amend Division of Fisher Scientific Co., and Taylor Instrument Cos.

Several other ASTM members were active at the meeting; E. J. Albert, Thwing-Albert Instrument Co., is a new Director of the Association and will continue as President *pro tem.* R. M. Wilhelm, Miller & Weber, Inc., chairman of the Bureau of Standards Committee, reported on the activities of his group, and J. J. Moran, Kimble Glass Co. heads the SAMA Standardization Committee.

Colonel Evan E. Kimble, founder of Kimble Glass Co., received the SAMA award for outstanding service for his pioneering work in making available chemical glassware, especially in accurate tubing, and for his other outstanding work.

The ASTM BULLETIN was represented in a public information program forum for editors, the subject discussed being "What Does America Expect From the American Scientific Instrument Industry?" Messrs. Walter J. Murphy, Editor, American Chemical Society Publications; Gerard Piel, Editor and Publisher, *Scientific American;* Paul Block, Publisher, *Toledo Blade* and *Pittsburgh Post Gazette*, and R. J. Painter, Associate Editor ASTM BULLETIN, formed the panel which was organized by Harlan Hobbs, Kimble Glass Co., Chairman, Public Information Committee of SAMA.

An important announcement at the meeting concerned the recognition of the scientific instrument industry as one of the essential industries with appropriate controls established so that the necessary materials can be procured to produce the instruments and equipment necessary for industry to operate efficiently. J. H. Kincaid, Chief of Scientific Instruments Section, Scientific and Technical Equipment Division, National Production Authority, described various aspects of priority controls, and Walter C. Skuce, Staff Assistant to the Administrator, National Production Authority, and in charge of CMP matters, told how the latter will operate.

Frequent reference was made to ASTM at the meeting. Dr. R. D. Thompson, Head of Glass Products Research and Engineering Division, Taylor Instrument Cos., in his paper "Methods of Testing Glass Thermometers" cited at several points the work of Subcommittee 17 (of ASTM Committee E-1) on thermometers.

The new President of SAMA is J. Clair Evans, Denver Fireclay Co., and succeeding E. J. Albert, Thwing-Albert Instrument Co., as chairman of the Industrial Instrument Section is Dr. G. A. Downsbrough, Boonton Radio Corp. A. W. Fisher, Fisher Scientific Co., is succeeded as chairman of the Laboratory Apparatus Section by Dr. F. F. Shetterly, Corning Glass Works.

ISO Committee on Textiles to Meet

A FURTHER meeting of ISO Committee 38 on Textiles is being held in Bournemouth, England, June 4–9, the last meeting of the committee having been held in Buxton, England, in 1948. Quite a number of topics of interest to American industry will come up for discussion at this meeting of the International Standards Organization, including the shrinkage of fabrics in washing, analysis of fiber mixtures, and the colorfastness tests with particular reference to light, washing, and prespiration. In connection with all of the above subjects the United States holds the secretariat for the subgroup, either

independently or jointly, with the British. The direction of twist is also scheduled for discussion in the hope of getting unanimous approval for adoption as American Standard of the S and Z twist designation since 21 countries have already accepted this designation. The universal yarn numbering system and the subject of tensile strength testing of fabrics as well as the testing of yarns and fibers are also of considerable importance.

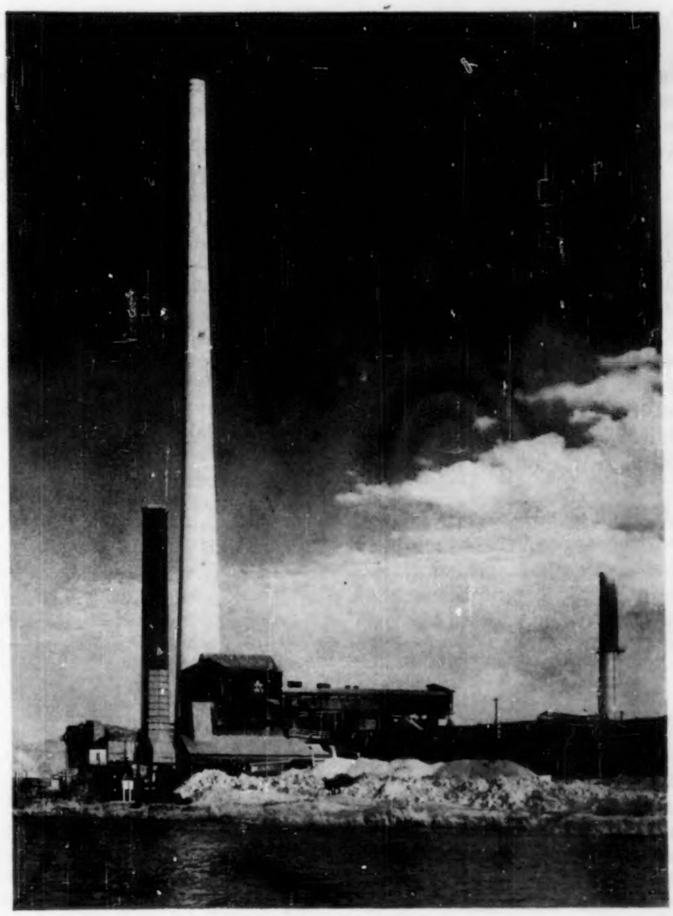
The American delegation will include at least 12 individuals, most of them members of ASTM Committee D-13. The ASTM has designated the chairman of Committee D-13, W. D. Appel, and A. G. Scroggie as its official delegates.

The meeting of ISO Committee 38 is being timed so that the representatives from other countries may also attend the meeting of the British Textile Institute which is being held in Brighton, England, the latter part of May. Dr. Appel has been honored by being asked to preside at one of the sessions of the Textile Institute meeting. A. G. Ashcroft, a member of the ASTM Administrative Committee on Ultimate Consumer Goods and former member of the Board of Directors, is to present a paper at the Textile Institute meeting.

During the past year American participation in ISO Committee 38 has been handled by a special subcommittee of Sectional Committee L-14 on Textile Test Methods. It was felt, however, that American industry's interest in this work was considerably broader than might be expected to be represented under a committee organized primarily to cover methods of testing. It would also seem preferable to have American industry represented directly in a matter of this sort rather than indirectly as would be the case under L-14. Accordingly an American group is being organized under the joint sponsorship of ASTM and the American Association of Textile Chemists and Colorists to consist of representatives of all American interests concerned.

Symposium on Analysis and Metallography of Titanium

The analysis and metallography of titanium is the subject of a symposium to be sponsored by Armour Research Foundation of Illinois Institute of Technology June 11 through 13 at Chicago, Ill. The symposium is divided into five sessions on: Chemical Methods for Commercial Titanium and Commercial Alloys; Chemical Methods in Titanium Alloy Development; Determination of Oxygen; Instrumental Methods, and finally Metallography.



World's Tallest Chimney

Reinforced Concrete Chimney Built to Record Height of 611 Feet; ASTM Standards Used

Located at the El Paso plant of the American Smelting and Refining Co., the world's tallest chimney completed in October, 1950, is 611 ft high above the top of its foundation, having an internal top diameter of 14 ft. This tall chimney was required to minimize any chance of gases containing $\frac{1}{2}$ to 1 per cent of sulfur dioxide becoming a pollution factor under unfavorable atmospheric conditions.

The specifications applied in the construction called for the cement, aggregates, and reinforcing steel to conform to the latest ASTM requirements and required 3 lb of Cellite to be added as an admixture to each bag of cement. A masonry lining was not required since the gases passing through the chimney are fairly cool and not highly corrosive. The interior, however, was painted with a special coal-tar paint to protect the concrete from possible attack by corrosive constituents of the gas.

The ASTM Standards called for in the specifications for this chimney are as follows:

- Specifications and Tests for Portland Cement, C 150.
- Specifications for Concrete Aggregate, C 33.
- Specifications for Deformed Billet-Steel Concrete Reinforcement Bars, Intermediate Grade, A 15.
- Making Compression Tests of Concrete, C 39.
- Specification for Rolled Wrought Iron Shapes and Bars, A 207.

At a level of 13 ft below the present grade, hard gravel was encountered and loading tests indicated a design soil loading of 8500 psf. The foundation is 8 ft thick, of which the lower 2 ft 6 in. is an octagonal slab 66 ft 6 in. wide across the flats, and the remaining 5 ft 6 in. slopes inward to an octagon measuring 46 ft across the flats at the top. The foundation required 2040 cu yd of excavation, 880 cu yd of concrete, 38 tons of reinforcing steel, and 875 cu yd of backfill.

The bottom outside diameter of the chimney is 44 ft 10 in; wall thickness at the top and bottom is 9 in. and 25 in.,

respectively. The extreme top of the chimney is protected by a sectional cast iron cap having a minimum material thickness of $\frac{5}{8}$ in. The sections of the cap are bolted together with stainless steel bolts, and the cap is electrically connected to the lightning protection system.

The chimney was designed and built by the Custodis Construction Co., a construction firm which has designed and built industrial chimneys for the past 52 years.

The American Smelting and Refining Co. has been a member of ASTM for many years, and is at present a sustaining member, with S. J. Dickinson, Technical Adviser, the official representative.

Dr. A. J. Phillips, Manager of Research Department, has been a member of ASTM for many years and has been very active in ASTM committee work, particularly on Committee B-5 on Copper and Copper Alloys.

The Behavior of Engineering Metals

H. W. Gillett is gone, but, as Clyde Williams, Director of Battelle, notes in his foreword to this interesting book, one of Gill's last acts before his untimely death was to write "Finis" on the manuscript for this book. All of the abilities which this outstanding American metallurgist had are combined in this publication which has been termed "concentrated metallurgical know-how."

The author states the purpose of the book "to help those who are not metallurgists but who participate in the selection of metals and alloys for engineering uses." Nevertheless, we feel many metallurgists in both the ferrous and non-ferrous fields would find the publication of service and value.

The selection of the proper alloy for a given use is complex and increases with the number of materials and their various forms available. Quoting from the preface,

"This book undertakes to present the viewpoint of the metallurgist for those who have not specialized in this field. Since it is intended to help in choosing suitable engineering materials, the behavior of these materials is discussed rather than the sometimes abstruse theories that seek to explain their behavior. This is no criticism of theory; the metallurgist cannot hope to control behavior without a clear picture of its causes. But the nonspecialist may properly content himself with the engineering facts that are pertinent to his own work. Following the same reasoning, technical terms have been used as little as possible, and references have been selected, where a choice existed, for easy reading as well as for technical content. In spite of these efforts at simplicity of presentation, no known liberties have been taken with technical facts. Some facts are intentionally repeated in different chapters, because the same behavior may assume varying degrees of importance depending on the surrounding circumstances."

The opening chapters relate to basic concepts such as metallurgical terminology, conventional mechanical tests, etc. There is a discussion of tests and specifications and simulated service; then stress concentration and references to statistical approach, and finally an interesting chapter on chemical and physical properties. Succeeding chapters cover tonnage steels, wrought steels of intermediate strength, heat-treated steels, cold-worked metals, ferrous castings, castings in general including non-ferrous, light alloys, common heavy metals, precious metals, and then closing chapters are on such topics as machinability; special fabricating techniques; means of using or selecting metals so as to combat the effects of corrosion, wear, and high temperature; and some "tricks of the trade." The vital factors of cost and availability are the subject of the closing chapter.

"Gill's" books and papers were always extremely well documented, and this is no exception. His references, hundreds in number, include a great many to ASTM publications—standards, *proceedings*, and the special technical books.

Dr. Gillett, with a profound knowledge of the fundamentals of metals, had an uncanny faculty for placing theory and practice in their proper perspective and of expressing this relationship in what might be termed "homespun language." For example, his chapter in this book on stress concentration opens as follows: "Metals are allergic to notches. A notch concentrates the stress at its apex. Instead of the cross-section merely being reduced, with the stress uniformly distributed over the section, one tiny location is called upon to withstand very much more stress than it would have to stand were it not facing the notch."

It is pertinent to record a reference in the book on acceptance testing quoting words from another wise authority on materials, Lawford H. Fry. Concerning the principles of specifications, Fry wrote and Gillett quoted as recorded in the accompanying box.

Complete with both an author and detailed subject index, this 412-page publication, 6 by 9 in., is published by John Wiley & Sons and is available at $6.50.

Principles of Specifications[1]

From the book "Behavior of Engineering Metals"

"The purpose of these specifications should be clearly understood. *They do not serve to explore the hidden properties of materials in order to inform an inexperienced designer as to the uses to which a given material may be put.* Metallurgical research may work to this end, but the acceptance specifications aim at another usefulness. It may be humbler but it is highly important.

"An engineer designs a structure using certain materials and finds that it is satisfactory. He then wants to put it into production and to obtain a continuing supply of materials like those which have given good results. The steel specifications have been provided to control the supply of the steel required, to insure as far as is practicable that the type and quality of the steel supplied shall remain uniform.

"The primary responsibility of the specifications is to insure a flow of uniform material, but their secondary responsibility is to see that control of this uniformity is effected without undue wear and tear on the nerves of the supplier. This concern for the supplier is not altruism on the part of the user. It is based on the realistic understanding of the fact that complexity in testing produces an increase in cost which by the immutable laws of economics is borne by the purchaser. Test requirements which serve no useful purpose waste time and increase the cost of manufacture to no good end.

"Tension testing is one of the requirements put into the specifications in the attempt to secure uniform material. If uniform results are to represent uniform material, the conditions under which the results are obtained must be kept uniform."

[1] Quoted by the author, H. W. Gillett, from Lawford H. Fry's 1948 paper.

Government Patents Board

The Government Patents Board is a new, independent agency providing for a uniform patent policy for the Government with respect to inventions by Government employees.

The new Board has as its Chairman, A. M. Palmer, since 1946 a Director of the Patent Policy Survey of the National Research Council.

The Government Patents Board consists of the Chairman and representatives of 10 Government agencies. The Chairman consults and advises with Government agencies concerning the application and operation of a uniform patent policy; formulates and submits to the President of the United States for approval such rules and regulations as may be necessary or desirable to implement and effectuate such policies; submits an annual report to the President, on the operation of such policies; and the Chairman determines with finality the controversies or disputes between any Government agency and its employees concerning the ownership of inventions made by such employees or the rights therein.

PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

ASA Personnel News

Several active ASTM men have been elected recently to important committee responsibilities in the American Standards Association. **Myron Park Davis II,** Chief Chemist and Metallurgist, Otis Elevator Co., is the new Chairman of the Safety Code Correlating Committee on which he represents ASTM. **Theodore I. Coe,** Technical Secretary, Department of Education and Research, The American Institute of Architects, has been re-elected Chairman of the Building Code and Construction Correlating Committee, in which he has had an important part for several years. **Frank T. Ward,** Vice-President, Hunter Illuminated Car Sign Co., is Chairman of the ASA Mechanical Standards Committee, representing the American Transit Association; and **L. W. Kattelle,** Assistant Chief Engineer, Walworth Co., is serving as Vice-Chairman.

Max I. Beard, formerly Metallurgist, Automotive Gear Works, Inc., Richmond, Ind., is now associated with the Columbus Anvil & Forging Co., Columbus, Ohio, as Heat Treat Supervisor.

John M. Bierer has been named President of Boston Woven Hose & Rubber Co., Cambridge, Mass., filling a vacancy created by the recent death of President J. Newton Smith. Mr. Bierer, who in January was made Executive Vice-President, started with the company in 1911 as a chemist, and following several promotions became factory manager in 1929, being elevated to the vice-presidency in 1944. He has been a director of his company since 1932. Affiliated with ASTM since 1913, Mr. Bierer has served on Committee D-11 on Rubber and Rubber-Like Materials and a number of its subgroups for many years.

William Blum, Chief of the National Bureau of Standards Electrodeposition Section, was honored recently by the Electrodepositors' Technical Society of London by his election as an honorary member. The Society, consisting of chemists metallurgists, and other specialists in the electroplating field, has elected only six honorary members in its twenty-six years of existence.

Frederick Charles Brightly, Jr., formerly Vice-President, Standard Galvanizing Co., Oak Park, Ill., is now President, Brightly Galvanized Products, Inc., Cicero, Ill.

E. H. Bunce, until recently Manager, Research Department, The New Jersey Zinc Co. (of Pa.), Palmerton, Pa., has been appointed Assistant to the President of his Company, with headquarters in New York. **George F. A. Stutz** succeeds Mr. Bunce in the Research Department at Palmerton.

Francis M. Buresh has accepted appointment as Consulting Textile Engineer, Curlator Corp., Rochester, N. Y.

Joseph G. Christ, formerly Metallurgical Engineer, Westinghouse Electric Corp., Pittsburgh, is now affiliated with the Ferrotherm Co., of the same city, in a similar capacity.

Milford H. Corbin, President of the Standard Varnish Works, New York, has been elected President of the Standard Varnish Works, Chicago, replacing Edward E. Day, who has been elected chairman of the board of the Illinois Corporation. Mr. Corbin has assumed presidency of both the New York and Illinois companies.

W. P. Dobson, Director of Research, Hydro-Electric Power Commission of Ontario, Toronto, has recently received signal recognition for his outstanding work in the Canadian Standards Association by election as an Honorary Life Member. Active in the CSA since 1919, he serves on many of its important technical groups. One of his important contributions was in connection with the Approvals Administrative Procedure, and he headed the CSA Approvals Council as Chairman for ten years. Mr. Dobson has been a member of ASTM for many years, representing the sustaining membership of the Hydro-Electric Power Commission.

Arno C. Fieldner, associated with the Bureau of Mines for over four decades and internationally known inventor and developer of techniques for testing and analyzing coal, coke and gas, has been named Chief Fuels Technologist on the staff of Director Boyd of the Bureau. He will serve as adviser, technical specialist, and general authority for the Bureau on scientific problems in fuels technology. For many years, Dr. Fieldner has been Chief of the Bureau's Fuels and Explosives Division. A Past-President and Honorary Member of ASTM, Dr. Fieldner has been affiliated with the Society since 1914, rendering valuable service through the years on many of the technical committees, in particular Committee D-3 on Gaseous Fuels of which he was Chairman 1935–1940, and Committee D-5 on Coal and Coke where he served as Chairman from 1920 to 1948. (Also see note on Dr. L. C. McCabe.)

Samuel Garber is now Chief, Chemical Engineering Section, Specifications Branch, Engineer Res. and Dev. Labs., T.E.C., Ft. Belvoir, Va.

Allen S. Ginsburgh, formerly associated with Andrew Alford Consulting Engineers, Boston, Mass., is now Development Engineer, Aerojet Engineering Corp., Azusa, Calif.

Lawrence J. Gorman, formerly with the Consolidated Edison Company of New York, is now affiliated with Robin Beach Engineers Associated, Brooklyn, N. Y. An authority in the field of electrolytic corrosion, Mr. Gorman for many years has been a member of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, serving on several of its subgroups and as Chairman of its Subcommittee on Galvanic and Electrolytic Corrosion.

J. H. Goshorn, until recently Assistant Chief Engineer, Ohio State Highway Testing & Research Lab., Columbus, is now District Engineer, The Asphalt Institute, Cincinnati, Ohio.

Hatch Textile Research Service, **Herbert H. Hatch,** Director, is this year celebrating its 25th Anniversary. Specializing in textile testing, this organization is completing a quarter century of work in this field. A member of the Society for several years, Mr. Hatch serves on Committee D-13 on Textile Materials.

Donald LaVelle, Metallurgist in Charge of Aluminum Research, Federated Metals Division, American Smelting and Refining Co., recently addressed the Northwestern Pennsylvania Chapter of the AFA in Erie, Pa., on "Aluminum Casting Defects and Their Correction," presenting many slides depicting the various types of such defects. Mr. LaVelle represents his company on ASTM Committees B-6 on Die-Cast Metals and Alloys, and B-7 on Light Metals and Alloys, serving on several of their subgroups.

Louis C. McCabe, Assistant Chief of the Fuels and Explosives Division, U. S. Bureau of Mines, and also Chief, Air and Stream Pollution Prevention Research for the Bureau, was promoted recently to Chief of the Fuels and Explosives Division in Washington, D. C. He will advise Director Boyd in the planning and execution of the Bureau's broad program of research and experimentation in fuels utilization, petroleum and natural gas, helium, coal, and explosives. Dr. McCabe's career includes several years in the Army in World War II when he was on the Supreme Headquarters' Staff in Europe.

Paul D. Merica, Executive Vice-President and a Director, The International Nickel Co., New York City, has been elected a member of both the Executive Committee and the Advisory Committee of the Company.

Everett P. Partridge, Director, Hall Laboratories, Inc., Pittsburgh, has been elected to the Board of Directors of Hagan Corporation, combustion control engineering concern, and its subsidiaries, Hall Laboratories, Inc., and Calgon, Inc.

Perry H. Petersen, formerly Structural Research Engineer, Housing & Home Finance Agency, Washington, D. C., is now Director, Materials Div., U. S. Naval Civil Engineering Research & Evaluation Laboratory, Port Hueneme, Calif.

Raymond A. Pingree has accepted a position as Technical Director, Crown

Chemical Corp., Providence, R. I. He was previously associated with the Warwick Chemical Co., Div. of Sun Chemical Corp., Wood River Junction, R. I., as Chemical Director.

Carlton S. Proctor, New York City consultant with a long record of professional and civic achievement, was nominated for 1952 President of the American Society of Civil Engineers. A member of ASCE since 1925, Mr. Proctor has served it with distinction in several important posts Associated with the consulting firm of Moran, Proctor, Freeman & Mueser, which specializes in substructure engineering, Mr. Proctor has served as a Consulting Associate Member of ASTM Committee D-18 on Soils for Engineering Purposes for many years.

John C. Riedel, Chief Engineer for the Board of Estimate, New York City, was honored recently for 50 years of service to the City. The Board passed a resolution commending him "for his great service to the people of the City." Affiliated with ASTM since 1921, Mr. Riedel has been active for many years in the work of Committee C-4 on Clay Pipe, and Committee C-15 on Manufactured Masonry Units, serving on many of their subgroups.

Philip K. Roos, Associate Professor of Engineering Mechanics, The Pennsylvania State College, is on a year's leave of absence from the College, being presently engaged in special work as Engineer, Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.

R. B. Saltonstall, Technical Director, Udylite Corp., Detroit, Mich., was among a number of employees of his company recently honored for 15 years of continuous service. Dr. Saltonstall is the present Chairman of ASTM Committee B-8 on Electrodeposited Metallic Coatings and for several years has served also on other of non-ferrous groups as well as Committee A-5 on Corrosion of Iron and Steel.

Raymond H. Schaefer has been elected a Vice-President of American Brake Shoe Co., New York. He joined the company in 1940, became Chief Metallurgist in 1945, and two years later was appointed Director of Research and Development. He continues in charge of the company's research activities.

Max Schuster, formerly with Kanmak Textiles, Inc., New York City, is now associated with Burlington Mills Corp., of the same city.

Howard R. Staley, until recently on the faculty of the Massachusetts Institute of Technology as Associate Professor of Building Construction, is now with the U. S. Atomic Energy Commission, Silver Spring, Md., in the capacity of Construction Engineer.

Mr. and Mrs. **Thomas G. Stitt** on April 18 celebrated their Golden Wedding Anniversary. The Society extended congratulations through a telegram from the Executive Secretary, and many of the friends and associates of Tom, as he is affectionately known throughout the Society, had heard of the event and extended best wishes. Active in the Society for many years, and representing the Pittsburgh Steel Co., of which he is Chief Inspecting Engineer, he has a notable record of accomplishment as the Chairman of the Steel Committee's Subcommittee IX on Pipe and Tubing, and has served ASTM in other capacities. His work was recognized in 1950 when he received the new ASTM Award of Merit.

John F. Thomson, President of The International Nickel Company of Canada, Ltd., Copper Cliff, Ontario, has been elected to the additional office of Chairman of the Board of Directors of his Company.

G. N. Vacca, of Bell Telephone Laboratories, Inc., Murray Hill, N. J., has been made a member of the Wire & Cable Technical Committee of the Industry Operations Bureau, National Production Authority.

NEW MEMBERS...

The following 125 members were elected from March 14, 1951, to April 23, 1951, making the total membership 6942 ... Welcome to ASTM

Note—Names are arranged alphabetically—company members first, then individuals

Chicago District

Admiral Corp., B. Keith Peter, Engineer, 3800 W. Cortland St., Chicago 47, Ill.

Arndt, Herbert, Chemist, Midwest Manufacturing Corp., Galesburg, Ill.

Bailey, Fred Coolidge, Research Engineer, Caterpillar Tractor Co., Peoria, Ill. For mail: 117 Pontiac Rd., Marquette Heights, Pekin, Ill. [J]*

Chicago Housing Authority, R. H. Flindt, Chief of Construction, 608 S. Dearborn St., Chicago 5, Ill.

Friedlaender, William V., Section Leader, Universal Atlas Cement Co., Research Labs, Buffington Station, Gary, Ind.

Holcomb, William D., Engineer, Reliable Electric Co., 3145 Carroll Ave., Chicago 12, Ill.

Kelly, Richard W., Partner, Walsh & Ikeler, R.R. No. 2, Gary, Ind. For mail: 123 S. Twentieth St., Terre Haute, Ind.

MacLaren, F. H., Group Leader, Standard Oil Co. (Indiana), Research Dept., Whiting, Ind.

McCoy, James P. A., Chemical Engineer, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Stoner, John D., Factory Manager, Monroe Auto Equipment Co., Hillsdale, Mich.

Teesdale, Laurence V., Engineer, U. S. Forest Products Laboratory, Madison 5, Wis.

Tonetti, John E., Engineer, Bituminous Materials Co., Inc., Box 267, Terre Haute, Ind.

University Farm Library, St. Paul 1, Minn.

Wilson, Harold W., Chief Analytical Chemist, American-Marietta Co., 901 N. Greenwood Ave., Kankakee, Ill. For mail: Route 2, Sand Bar Beach Rd., Kankakee, Ill.

Young, M. K., Chief Metallurgist, The Electric Auto-Lite Co., Woodstock, Ill. For mail: 220 W. Calhoun St., Woodstock, Ill.

Cleveland District

Osborn Manufacturing Co., The, R. O Peterson, Manager, Technical Dept., 5401 Hamilton Ave., Cleveland 14, Ohio.

Matthews, Norman A., Division Metallurgist, Electro Alloys Div., American Brake Shoe Co., Taylor St., Elyria, Ohio.

von Fischer, William, Professor, Case Institute of Technology, University Circle, Cleveland 6, Ohio.

Vreeland, John J., Metallurgical Engineer, Chase Brass and Copper Co., Inc., 1121 E. 260th St., Cleveland 17, Ohio.

Detroit District

Giffels & Vallet, Inc., O. H. Pocock, Chief Engineer, 1000 Marquette Bldg., Detroit 26, Mich.

Beck, C. W., Jr., President, Motor Specialties Corp., 12255 E. Eight Mile Rd., Detroit, Mich. For mail: Box 3808, Detroit 5, Mich.

Munger, John C., Field Chief, McMahon Engineering Co., 11621 E. Jefferson, Detroit, Mich. For mail: 459 Townsend, Birmingham, Mich. [J]

Printz, Leon J., Chief Metallurgist, Amplex Manufacturing Co., Division of Chrysler Corp., 6501 Harper Ave., Detroit 11, Mich.

New England District

Providence Combing Co., C. L. Kingman, Superintendent, Box 136, Olneyville Station, Providence, R. I.

Egan, Charles H., Vice-President, Research, Dewey & Almy Chemical Co., 62 Whittemore Ave., Cambridge, Mass.

Sterner, John, Vice-President, Baird Associates, 33 University Rd., Cambridge 38, Mass.

New York District

General Stencils, Inc., Joseph Klugman, Secretary, 129 Lafayette St., New York 13, N. Y.

Beede, Harry L., Technical Manager, Okonite Callender Cable Co., Paterson, N. J. For mail: 730 Twenty-first Ave., Paterson 3, N. J.

Buc, George L., Physicist, Calco Chemical Div., American Cyanamid Co., Bound Brook, N. J.

Crandall, E. R., Chief Engineer, The Mullite Refractories Co., Canal St., Shelton, Conn.

Eddy, Francis T., Superintendent of Finishing, Chase Brass and Copper Co., Inc., 236 Grand St., Waterbury 20, Conn.

Gewinner, Alvin L., Research Chemist, Mohawk Carpet Mills, Inc., Amsterdam, N. Y.

Green, D. H., Manager, Automotive Engineering Dept., National Carbon Division, Union Carbide and Carbon Corp., 30 E. Forty-second St., New York 17, N. Y.

Haynes, Charles R., Manager, Rubber Service, Binney & Smith Co., 41 E. Forty-second St., New York 17, N. Y.

Legg, Victor E., Engineer, Magnetics Applications, Bell Telephone Laboratories, Murray Hill, N. J.

Marcley, Clarence B., Chemist, General Electric Co., Works Lab., Bldg. 4, Schenectady, N. Y.

McGraw, James E., Materials Engineer, General Electric Co., Works Lab., Bldg. 6-108, Schenectady, N. Y.

Mountsier, S. R., Jr., Manager, Technical Service Dept., Whittaker, Clark & Daniels, Inc., 260 W. Broadway, New York 13, N. Y.

Mueser, William H., Partner, Moran, Proctor, Freeman & Mueser, 420 Lexington Ave., New York 17, N. Y.

Quasebarth, K. H., RFD 1, Hicksville, N. Y.

Smith, Francis G., Manager, Paint Test Station, Titanium Pigment Corp., Box 404, Sayville, N. Y.

Steig, Fred B., Jr., Laboratory Manager, Titanium Pigment Corp., 99 Hudson St., New York, N. Y.

Stibbl, Frederick, Research Metallurgist, Arma Corp., Research and Development Dept., Components Sections, 254 Thirty-sixth St., Brooklyn 32, N. Y.

Ward, Frank T., Vice-President, Hunter Illuminated Car Sign Co., 30-48 Linden Pl., Flushing, N. Y. For mail: Chestnut Hill Rd., R.D. No. 2, Wilton, Conn.

Wedemeyer, Henry, Manager, Seam Research Labs., Singer Sewing Machine Co., 561 Broadway, New York 12, N. Y.

Weisberg, Herman, Mechanical Engineer, Public Service Electric and Gas Co., 80 Park Pl., Newark 1, N. J.

Work, Robert W., In Charge of Physical Research Dept., Celanese Corporation of America, Celanese Research Labs., Morris Court, Box 1000, Summit, N. J.

Northern California District

National Motor Bearing Co., Inc., Vanderveer Voorhees, Director of Research and Patents, Broadway and National, Redwood City, Calif.

Baird, Ronald M., Technical Director, National Lead Co., Pacific Coast Branch, 2240 Twenty-fourth St., San Francisco, Calif.

Ohio Valley District

National Tile and Manufacturing Co., Earl E. Baldauf, Manufacturing Manager, 1200 E. Twenty-sixth St., Anderson, Ind.

North American Aviation, Inc., F. A. Wedberg, Section Head, Materials Lab., 4300 E. Fifth Ave., Columbus 16, Ohio.

Calkins, George D., Research Chemist, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.

Covington, City of, E. B. Abbett, City Manager, City Bldg., Covington, Ky.

Cummins, Edgar W., Engineer in Charge, Research Section, Ohio State Highway Testing and Research Laboratory, Ohio State University Campus, Columbus 10, Ohio.

Krishnaswamy, R., Research Fellow, Ohio State University, Columbus 10, Ohio. For mail: 48 W. Woodruff Ave., Columbus 1, Ohio.

Reid, William T., Research Supervisor, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.

Williams, Frank Myron, Assistant Chief Engineer, Ohio State Highway Testing and Research Laboratory, Ohio State University Campus, Columbus 10, Ohio.

Wood, L. A., Supervising Engineer RCA Victor Division of Radio Corporation of America, 501 N. LaSalle St., Indianapolis, Ind.

Philadelphia District

Piasecki Helicopter Corp., W. J. Wilson, Chief Process Engineer, 100 Woodland Ave., Morton, Pa.

Cameron, D. D., Technical Service Engineer, Hercules Powder Co., Wilmington, Del.

Field, Hugh W., Vice-President and General Manager, Research and Development Dept., The Atlantic Refining Co., Box 8138, Philadelphia 1, Pa.

Irvine, James Bosworth, Product Service and Evaluation Supervisor, Quaker Chemical Products Corp., Conshohocken, Pa. For mail: Wayland Rd., R.D. 1, Collegeville, Pa.

Jenni, Clyde B., Metallurgist, General Steel Castings Corp., Eddystone, Pa.

Kraus, Max H., Procurement Standards Engineer, Eckert-Mauchly Computer Corp., 3747 Ridge Ave., Philadelphia 32, Pa. [J]

Pittsburgh District

Joy Manufacturing Co., T. H. Troller, Vice-President, Engineering, 333 Oliver Bldg., Pittsburgh 22, Pa. [S]**

Sharon Steel Corp., A. M. Tredwell, Jr., Vice-President, Sharon, Pa.

Standard Steel Spring Co., G. B. Bowman, Chief Chemist, Plant No. 3, Coraopolis, Pa. [S]

Amspacher, Victor E., Chief Chemist, Pennsylvania Railroad Co., Test Dept., Seventeenth St. and Margaret Ave., Altoona, Pa.

Epremian, Edward, Research Metallurgist, Carnegie Institute of Technology, Metals Research Lab., Schenley Park, Pittsburgh 13, Pa.

Fink, William L., Chief, Physical Metallurgy Div., Aluminum Company of America, Aluminum Research Labs., Box 772, New Kensington, Pa.

Hodge, John M., Research Associate, United States Steel Co., 525 William Penn Pl., Pittsburgh 30, Pa.

Miller, Charles E., Packaging and Loading Engineer, United States Steel Co., 525 William Penn Pl., Pittsburgh 30, Pa. For mail: 4403 Center Ave., Pittsburgh 13, Pa.

Peterson, Axel H., Head, Department of Instrumentation, Mellon Institute of Industrial Research, Pittsburgh 13, Pa.

Robb, John F., Metallurgical Engineer, Climax Molybdenum Co., 479 Union Trust Bldg., Pittsburgh 19, Pa.

Whitehead, Donald E., General Lubrication Engineer, Crucible Steel Company of America, 2328 Oliver Bldg., Pittsburgh 22, Pa.

St. Louis District

McDonnell Aircraft Corp., G. L. Rogers, Chief Test Engineer, Box 516, St. Louis 3, Mo.

McFadden and Brothers, George H., P. M. Harding, Head Classer, Box 168, Memphis, Tenn.

Ambruster, H. Ralph, Purchasing Agent, The Carter-Waters Corp., 2440 Pennway, Kansas City 8, Mo.

Daniels, Orval W., Manager, Tulsa Testing Laboratory, 611 W. Douglas, Wichita, Kans. For mail: Box 2191, Wichita 1, Kans.

Leventhal, H. L., Technical Director, The Visking Corp., 1301 E. Eighth, N. Little Rock, Ark. For mail: 707 Skyline Dr., N. Little Rock, Ark.

Southern California District

Compton Foundry, James Barr, General Manager, 1320 S. Alameda St., Compton 1, Calif.

Dolan, Robert F., Treasurer, Joslyn Pacific Co., 5100 District Blvd., Los Angeles 58, Calif.

Washington (D. C.) District

Natural Rubber Bureau, Harry K. Fisher, Rubber Road Consultant, 1631 K St., N. W., Washington 6, D. C.

Brink, Russell H., Materials Engineer, Bureau of Public Roads, Washington 25, D. C.

Butler, Francis E., Naval Research Laboratory, Washington, D. C. For mail: 3752 Hayes St., N. E., Apt. No. 3, Washington 1, D. C. [J]

Carlson, Elmer T., Chemist, National Bureau of Standards, Washington 25, D. C. For mail: 121 N. Columbus St., Arlington 3, Va.

Hart, John H., Lieutenant Commander, U. S. Department of the Navy, Bureau of Ships, Washington, D. C. For mail: 1549 Mt. Eagle Pl., Alexandria, Va.

Long, James R., Principal Metallurgist, U. S. Bureau of Mines, College Park, Md.

Nolan, Arthur, Vice-President and General Manager, Latex and Rubber, Inc., 1075 Hull St., Baltimore 30, Md.

Ryan, Victor A., Director of Research, Crown Cork and Seal Co., Inc., Baltimore 3, Md. For mail: 1506 E. Thirty-third St., Baltimore 18, Md.

Williams, W. Lee, Metallurgist, U. S. Naval Engineering Experiment Station, Annapolis, Md.

Western New York-Ontario District

Berns, Milton H., Director, Technical Service, Electro Refractories and Abrasives Corp., 344 Delaware Ave., Buffalo, N. Y.

Davis, Glenn N., Chief Draftsman, Farrel-Birmingham Co., Inc., 344 Vulcan St., Buffalo 7, N. Y.

Gallo, Michael R., Plant Metallurgist, Buflovak Equipment Division of Blaw-Knox Co., 1543 Fillmore Ave., Buffalo 11, N. Y.

Jewell, H. William, Chief of Research and Development, National Sewer Pipe Co., Ltd., 320 Bay St., Toronto 1, Ont., Canada.

Lowry, Raymond J., Superintendent, Quality Control, Hewitt-Robins, Inc., 240 Kensington Ave., Buffalo 5, N. Y.

McMillin, F. W., Jr., Engineer, McLain Construction Corp., 275 Mayville Ave., Kenmore 17, N. Y.

To the ASTM Committee on Membership

1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on membership in ASTM and include a membership application blank

Signed ______________________

Address ______________________

Date ______________ ______________________

U. S. and Possessions

SOUTHERN LABORATORIES, INC., John R. Bayliss, President, Box 346, Mobile 3, Ala.

ALDEN, RICHARD C., Chairman, Research Planning Board, Phillips Petroleum Co., Bartlesville, Okla.

CHUN, JAMES H. H., Engineer, Technical Div., Honolulu Construction and Draying Co., Ltd., 800 South St., Honolulu, T. H. For mail: 731 A Tenth Ave., Honolulu, T. H.

FLORIDA, UNIVERSITY OF, CIVIL ENGINEERING DEPT., S. L. Bugg, Professor of Civil Engineering, 106 Engineering Bldg., Gainesville, Fla.

FOWLER, FREDERICK E. W., Construction Superintendent and Chief Inspector, U. S. Department of the Navy, Bureau of Docks, c/o OINCC, NOy 13913, Navy No. 230, c/o PM, Seattle, Wash.

HELMER, RICHARD A., Chief Engineer, Standard Testing and Engineering Co., Box 6157, Oklahoma City, Okla. For mail: 1322 N. Blackwelder, Oklahoma City, Okla.

HOLMBERG, M. E., Manager, Test Div., Phillips Petroleum Co., Bartlesville, Okla. For mail: 1316 Keeler, Bartlesville, Okla.

HOUSTON, UNIVERSITY OF, LIBRARY, 3801 St. Bernard St., Houston 4, Tex.

KALENICH, WAYNE A., Librarian, Southwest Research Inst., Box 2296, San Antonio 6, Tex.

LEWIS, JOHN A., Research Assistant Engineer, Texas Engineering Experiment Station, Box 1645, College Station, Tex.

MINCKLER, HOWARD G., Highway Engineer, Alaska Road Commission, c/o General Delivery, Juneau, Alaska. [J]

OAK RIDGE NATIONAL LABORATORY, J. C. Morris, Chief Librarian, Box P, Oak Ridge, Tenn.

SMITH, HARRIS P., Professor, Agricultural Engineering, Texas Agricultural and Mechanical College, Agricultural Engineering Dept., College Station, Tex.

WHITENER, ERNEST K., JR., Laboratory Supervisor, Container Div., International Paper Co., Georgetown, S. C.

Other than U. S. Possessions

BURMAH OIL CO., LTD., THE, Research Dept., Fairlawn, Honor Oak Rd., Forest Hill, London S.E. 23, England.

FABRICA DE LADRILLOS INDUSTRIALES Y REFRACTORIOS, S. A., Salvador Odriozola Gomez, General Manager, Box 390, Monterrey, N. L., Mexico.

SUMITOMO ELECTRIC INDUSTRIES, LTD., K. Kitagawa, Managing Director, 60 Okijima, Minamino-Cho Konohana-Ku, Osaka, Japan.

ASSOCIACAO BRASILEIRA DE NORMAS TECNICAS, Mario Brandt, Technical Assistant, Caixa Postal 1680, Rio de Janeiro, Brazil.

INSTITUTO NACIONAL DE RACIONALIZACION DEL TRABAJO, Alcala 95, Madrid, Spain.

INSTITUTO TECNICO INDUSTRIALE "ARTURO MALIGNANI," Via Manzoni n.2, Udine, Italy.

IVANOVSZKY, LEO Managing Director, Abril Corp. (Gt. B.), Ltd., Golden Mile Works, Bridgend (Glam.), England. For mail: 62 Park St., Bridgend (Glam.), England.

PEREZ L, ARMANDO, Lieutenant, Venezuelan Navy, Caracas, Venezuela. For mail: 226 S. Forty-sixth St., Philadelphia 39, Pa.

ROBINSON, R. BRUCE, Container Research Lab., Bathurst Power and Paper Co., Ltd., 205 Hodge St., Ville St., Laurent, P. Q., Canada.

RODES, RAFAEL CALVO, Aeronautical Engineer, Instituto Nacional de Tecnica Aeronautica, Torrejon de Ardoz, Madrid, Spain. For mail: Alberto Bosch 9, Madrid, Spain.

ROYAL MILITARY COLLEGE OF CANADA, J. Burgoin, Associate Professor, Department of Civil Engineering, Kingston, Ont., Canada.

VIEGAS, MAURO RIBEIRO, Architect; and Professor, University of Brazil, Rio de Janeiro, Brazil. For mail: Rua Martins Pena 54, Apt. 52, Tijuca, Rio de Janeiro, Brazil.

WAKIM, FADLO, Chemist, Trans-Arabian Pipe Line Co., Tapline, Sidon, Lebanon.

WILSON, GORDON CHARLES, Assistant Manager, Soil Mechanics, Ltd., 123 Victoria St., London S. W. 1, England. For mail: 36 West Ave., Worthing, Sussex, England.

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*[J] denotes Junior Member.
**[S] denotes Sustaining Member.

NECROLOGY...

The Death of the following members has been reported

A. L. DUVAL D'ADRIAN, President, Mississippi Valley Research Laboratory, St. Louis, Mo. (February 1, 1950). Member since 1937.

JAMES LOGAN FITTS, Consulting Mechanical Engineer, Warren Webster and Co., Camden, N. J. (Residence, Merchantville, N. J.). Member since 1925.

ALVIN C. GOETZ, Manager, Technical Service Department, Pigment and Oxide Division, The Eagle-Picher Co., Cincinnati, Ohio (March 21, 1951). Affiliated with ASTM since 1939, Mr. Goetz has been very active in the work of the Society, having been a member of Committee B-2 on Non-Ferrous Metals and Alloys, and of Committee D-1 on Paint, Varnish, Lacquer, and Related Products for the past eleven years, serving on many of the subgroups of both these main technical committees. He represented D-1 on the Advisory Committee on Corrosion, and was a member of Committee E-12 on Appearance for some years. He was also a member of the Technical Coordinating Committee for the Paint Industry, representing the National Association of Corrosion Engineers. He had been a member of the Ohio Valley District Council of ASTM since its organization in 1949. Mr. Goetz had been associated with Eagle-Picher since 1923. Stricken with a heart attack early in the year while on a business trip to Washington, soon after assuming a position as Chief of the Protective Coatings Section, National Production Authority, he was brought to Cincinnati and seemed to be recovering when he suffered a fatal attack. Pre-eminent in the field of paint and pigments, Mr. Goetz had served during World War II with the War Production Board as an authority on paint formulation.

L. C. HARRINGTON, Director, Division of Mines and Mining Experiments, and Dean, College of Engineering, University of North Dakota, Grand Forks, N. D. (February 3, 1951). Member since 1932. A native of Michigan, and graduate of the University of Michigan and the Michigan College of Mines, Dean Harrington died of an acute heart attack at the age of 71, after a long and active career as educator and consultant in his chosen field.

WILLIAM P. KUEBLER, Chief, Chemical Laboratory, Westinghouse Electric Corp., Philadelphia, Pa. (March 29, 1951). Representative of Westinghouse Corp. since 1932 on Committee D-2 on Petroleum Products and Lubricants, serving as a member of many of its subcommittees, and as Chairman of Section on Rusting of its Technical Committee C on Turbine Oils.

M. ALLAN WILSON, Assistant Chief Engineer, Delaware State Highway Dept., Dover, Del. (February 23, 1951). Representative of the membership of Delaware State Highway Dept. since 1938.

To the ASTM Committee on Membership, 1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below

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This company (or individual) is interested in the following subjects: (indicate field of activity, that is, petroleum, steel, non-ferrous, etc.,)

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Signed ____________________

Date______________ **Address**____________________

The Society Appoints . . .

Announcement is made of the following appointments of Society representatives

G. H. HARNDEN, General Electric Co., on ASA Sectional Committee B32 on Wire and Sheet Metal Gages, with J. W. Caum, ASRM Staff, as alternate.

A. G. ASHCROFT, Alexander Smith and Sons Carpet Co., on ASA Consumer Goods Committee.

R. C. THUMSER, Monsanto Chemical Co., on ASA Chemical Industry Correlating Committee, succeeding H. K. Nason, Monsanto Chemical Co.

M. REA PAUL, Frederic H. Rahr, Inc., on ASA Sectional Committee A13 on Scheme for Identification of Piping Systems.

H. J. BALL, Lowell Textile Institute and A. G. Scroggie, E. I. du Pont de Nemours & Co., Inc., on American group of ISO/TC/38 on Textiles.

G. P. THIGPEN, Southern Testing Labs., Inc., on ASA Sectional Committee A21 on Cast Iron Pipe, succeeding W. P. Putnam, resigned.

ARTHUR W. CARPENTER, The B. F. Goodrich Co., as ASTM representative at the Diamond Jubilee Meeting of the American Chemical Society to be held in New York, September 3–7, 1951.

LABORATORY SUPPLIES . . .

Catalogs and Literature and Notes on New or Improved Apparatus

Note—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses.

Catalogs and Literature

Strain Analyzer—A new bulletin, describing the "H-42A Strainalyzer," is announced by Baldwin-Lima-Hamilton Corp. The instrument, used in conjunction with Baldwin SR-4 resistance wire strain gages, is designed for dynamic strain and vibration studies from 0 to 50,000 cycles per second. Simultaneous observation and recording of four strains are possible.

Bulletin 331, Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

Resistance Wire Strain Gages—A new two-page bulletin describes, shows graphic performance, and gives specifications for ten new-type (temperature compensated) "SR-4" resistance wire strain gages. These gages are only slightly affected by temperature variations within certain ranges when bonded to steel or aluminum.

Bulletin 174, Baldwin-Lima Hamilton Corp., Philadelphia 42, Pa.

Universal Photomicrographic Camera—A new bulletin published by C. A. Brinkmann & Co. describes and illustrates the Model 4 photomicrographic camera. Among the features listed for the camera are: (1) interchangeable backs, (2) detachable bellows, (3) 35-mm. accessories, (4) vibration absorbers, (5) reversing system for the light beam for instant change-over from transmitted to reflected light and *vice versa*.

C. A. Brinkmann & Co., P. O. Box 532, Great Neck, L. I., N. Y.

Laboratory Apparatus—Scientific instruments, laboratory apparatus, and safety devices developed and introduced during the past two years are illustrated and described in a six-page folder published by Fisher Scientific Co. The folder lists 37 new items which have been made available since the company published its most recent catalog supplement.

Fisher Scientific Co., 717 Forbes St., Pittsburgh, Pa.

Automatic Colorimeter—A new data sheet published by the Minneapolis-Honeywell Regulator Co. describes the new Nickerson-Hunter Colorimeter which utilizes Minneapolis-Honeywell components. Sections of the data sheet are as follows: application, equipment required, principles and method of operation, standardization and operating sequence.

Instrumentation Data Sheet No. 10.10-3, Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.

Industrial X-Ray—A new brochure illustrates and describes the products and services available from the Picker X-Ray Corp.

Bulletin 21250, Picker X-Ray Corp., 300 Fourth Ave., New York 10, N. Y.

Radioactivity Measurement—Radiation Counter Laboratories, Inc., announce the publication of a newly revised edition of their 46-page catalog on instruments for measurement of radioactivity. The original material has been brought up to date by the inclusion of recently developed instruments and accessories, techniques, and equipment. The new catalog will prove useful to those anticipating setting up new laboratories to use radioisotopes and those who already have radioisotope-using laboratories. A glossary in the rear is helpful for the beginning worker.

Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill.

Laboratory Apparatus—Volume Four of "Scientific Apparatus and Methods," the quarterly publication of E. H. Sargent and Company, is now available. This 32-page publication features a review of literature on the use of the polarigraph in the insecticide industry. The catalog contains sections on new items, reinstated items, discontinued items, and changes in specifications.

E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Ill.

Laboratory Apparatus—Scientific Glass Apparatus Co. Inc., has just released a new 28-page edition of their publication entitled "What's New for the Laboratory"—No. 12 in the series. Illustrated and described are a number of new items—including laboratory clamps, a pail and dipper of special rubber-like material for handling corrosive chemicals, miniature type pumps, a handled beaker, a pocket-type thermometer, high-capacity glass condenser and adapters with metal coils. Over 30 different items are covered.

Scientific Glass Apparatus Co. Inc., Bloomfield, N. J.

Soil Testing Equipment—A 12-page catalog on new products in the soil testing apparatus line has been released by the Soil Testing Services, Inc. Included in the items illustrated and described in the bulletin are the new "SOILTEST" models of triaxial and consolidation apparatus and accessories, paraffin warmers, dispersion mixers, direct shear apparatus, laboratory and field California Bearing Ratio apparatus, humidifiers, humid boxes, the Terzaghi water level for differential settlement observations, classification sets, a portable indicating pyrometric controller, the Harvard miniature compaction apparatus and laboratory timers.

Catalog No. 3-51, Soil Testing Services, Inc., 4520 W. North Ave., Chicago 39, Ill.

Instrument Notes

Microphotometer—A new photomultiplier microphotometer for the precise measurement and comparison of light intensities from 20 micro-microlumens to 20 lumens at selected wave lengths is announced by the American Instrument Co. Among its applications are the following: film densitometry (color, radiation; black and white), colorimetry, turbidimetry, fluorispecular and diffuse reflectivity, opacity, glossimetry, luminescence, measurement of light intensities at selected wave lengths through a microscope, telescope, polariscope, spectroscope, etc. Complete details are given in the manufacturer's Bulletin 2190.

Bulletin 2190, American Instrument Co., Silver Spring, Md.

Concrete-Beam Tester—According to the manufacturer a new machine determines by direct reading the flexural strength of concrete-beam specimens having a cross-section of 6 by 6 in. and sufficient length to permit testing on a 18-in. span, according to ASTM C 78 or A.A.S.H.O. T-97. One division (one one-hundredth of a revolution) on the dial of the gage indicates an applied load of 120 lb, which corresponds to a flexural strength (modulus of rupture) of 10 psi. When the width or depth of the specimen beam varies from the nominal (6 by 6 in.) by more than 0.05 in., a correction factor must be applied. The machine is separable into three parts weighing 90, 70, and 35 lb—a total weight of 195 lb. Details are given in the manufacturer's Bulletin 2191.

Bulletin 2191, American Instrument Co., Inc., Silver Spring, Md.

Concrete Test Hammer—The availability of a new concrete test hammer for use in estimating the compression strength of concrete by measuring the rebound of a small spring propelled hammer is announced. A bulletin describing the hammer is available from the manufacturer. The bulletin describes construction fea-

tures, operating curves, and test procedure for determining compressive strength.

Arthur R. Anderson, 110 Woodbury Ave., Springdale, Conn.

Spectrometer—A direct-reading spectrometer, called the "Production Control Quantometer," for rapid analysis of metals, is announced by Applied Research Laboratories. This instrument is said to represent the most advanced unit of its type and is applicable to a variety of metals including stainless steel and similar materials, with additional uses in other inorganic fields being developed. Based on spectroscopic principles, it embodies the additional feature of providing pen-and-ink recorded analyses of samples, element by element, purportedly within a period of two minutes or less. The recording mechanism can produce multiple copies of these records for high-speed analytical control when desired.

Applied Research Laboratories, 4336 San Fernando Road, Glendale 4, Calif.

Cathodic Etcher—The availability of new, high vacuum equipment for cathodic etching and for studying metals by this new technique has been announced by Distillation Products Industries, a division of Eastman Kodak Co. Presenting to industry a new method for studying the grain structure of metals, the new etcher is based upon cathodic etching principles in which the sample of metal to be studied is bombarded with a glow discharge at certain low pressures. The unit is expected to be particularly useful for studying cold flow lines. The glow discharge which "etches" the surface of the metal being studied is produced by positive ions passing between an aluminum anode and the sample of metal to be studied. According to the announcement, the advantage of this technique lies in the fact that the etching is produced physically rather than chemically, so that there is less danger of forming oxides and other chemical artifacts.

Distillation Products Industries, Rochester 3, N. Y.

Micro Hardness Tester—Kent Cliff Laboratories have announced recently several major improvements in the "Kentron Micro Hardness Tester" used for making Knoop or Vickers Hardness Tests on metals, fine wire, small precision parts, plastics, glass, paint, ceramics, enamels and jewels, both natural and synthetic. The testing load range of this instrument has been increased tenfold. It now applies dead weight loads from 1 to 10,000 grams. The mechanical stage is designed so that the test specimen slides underneath high-powered objectives up to and including 1000× magnification—without disturbing the original focusing of the microscope. A new specimen vise for holding mounted specimens fits into the mechanical stage. This vise is indexed. By aligning Vise Index with an index scribed on the specimen mounting and recording the micrometer readings of the X and Y axes on the stage—impressions can be located readily any time after the original testing.

Kent Cliff Laboratories, P. O. Box 696, Peekskill, N. Y.

New Precision Glass Tubing Gauge—E. Machlett & Son are offering a precision micrometer type glass tubing gage. This gage embodies a precision micrometer scale with vernier permitting inside measurements from 0.01 mm to 5 mm. It can also be used effectively for measuring bores or circular openings for the sizes indicated. The needle is of hardened steel, and a needle cap is provided to protect the needle point when not in use.

E. Machlett & Son, 220 E. 23rd St., New York 10, N. Y.

Counter Tubes—A new counter tube called the RCL Fusion Seal Mica Window Counter, Mark 1, Model 5, is announced by the Radiation Counter Laboratories. In this counter the thin mica window is rigidly sealed using a strong low-temperature polymerizing fusion seal. A flange insures a large mica to glass area and the mica window is housed by a fitting to provide against breakage. This counter may be used in any installation in which the Tracerlab TGC-1 or TGC-2 is used. The Mark 1, Model 5 may be used at altitudes of 10,000 or less and is shipped in an airtight can.

Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill.

Moisture Meter—A new, all-purpose meter for measuring the moisture content of lumber, wood, plaster, and other materials of varying textures and consistencies has been introduced by the TAGliabue Instruments Div. of Weston Electrical Instrument Corp. Known as the TAG Moisturonic Moisture Meter Model 8008, the portable instrument features an overall range of from 2000 ohms to 20,000 meg-ohms, a considerably greater span than is available in previous models, as well as a larger scale for greater ease in reading. These factors make it possible for the meter to check the moisture content of materials heretofore not readily measured. The instrument can be used with any material capable of accommodating electrode probes.

Tagliabue Instruments Div., Weston Electrical Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

INSTRUMENT COMPANY NEWS ....

Announcements, changes in personnel, new plants and locations, and other notes of interest

BURRELL CORP. Guy H. Burrell, executive vice-president of the Burrell Corp., has announced the removal of the firm's offices and laboratories to new quarters at 2223 Fifth Ave., Pittsburgh 19, Pa. All needed facilities for the manufacture and distribution of scientific apparatus and laboratory chemicals have been brought together in one modern building.

CONSOLIDATED ENGINEERING CORP. announces its movement to a new and modern plant at 300 N. Sierra Madre Villa, Pasadena, Calif. Their former address was 620 N. Lake Ave., Pasadena. Purpose of the move is to provide better service for the company's customers.

PALO-MYERS INC., 97 Chambers St., New York, N. Y., announces that after March 1, 1951, the firm will be known as Palo Laboratory Supplies, Inc. The firm announces that the change does not indicate any change in ownership, personnel, or address. The decision to alter the previous company name was dictated by a desire to incorporate in the name an indication of the field covered by the firm.

TAYLOR INSTRUMENT COS., Rochester, N. Y. The year 1951 marks the 100th birthday of the Taylor Instrument Cos. Starting as a tiny partnership for making household thermometers and barometers, the business of Kendall & Taylor showed an inventory in 1851 listing total assets at \$919, of which \$600 was for "knowledge of the business." The company has since become a multi-million dollar corporation manufacturing some 8000 variations of its basic products and distributing them all over the world. Although instruments for consumer use comprise the oldest part of the present Taylor line, by far the largest is the industrial instrument division, which began in 1896, and in 1905 the first controllers were added to the industrial line. During World War II such vital processes as synthetic rubber and high octane gasoline were aided by control equipment made by Taylor. Taylor was chosen prime contractor in the development, design and manufacture of all process control instruments for the Gaseous Diffusion Plant of the Atomic Bomb Project at Oak Ridge, Tenn.

Bureau of Standards Notes

Several ASTM members were recently honored by the Bureau. William Blum, Chief of the Electrodeposition Section, and Assistant Chief of the Chemistry Division, received the Gold Medal Exceptional Service Award for "Outstanding Contribution to the Public Service, The Nation or Humanity." Meritorious Service Silver Medal Awards for "Service of Unusual Value" in their respective departments were received by Eugene F. Hickson, Chief (Retired), Paint, Varnish and Lacquer Section, Chemistry Division; Raymond L. Sanford, Chief Magnetic Section; Bourdon F. Scribner, Chemist in Charge of Spectrochemical Laboratory; and Wilmer H. Souder, Principal Physicist. Mr. Sanford was also given a "Length of Service" Award. All of these gentlemen have been active for many years in ASTM technical committee work.

American Electroplater's Society Convention

THE American Electroplater's Society at its annual convention in Buffalo, July 30–Aug. 2, will feature at its opening session a paper presented by Dr. William Blum of National Bureau of Standards on "Some Engineering Aspects of Plating Room Operation." Other symposiums to be presented will be on "Finishing and Plating of Diecastings," "Substitute Finishes," "Plating Control," and on "A.E.S. Research."

Highlights of Progress in Forest Products Research

By L. J. Markwardt[1]

EDITOR'S NOTE.—This paper was presented by President Markwardt at several meetings sponsored by various ASTM Districts. The presentation took the form of a lecture demonstration, Mr. Markwardt having many samples of representative materials to illustrate the paper. "President's Nights" at which Mr. Markwardt presented this paper, were held in the following cities: Cambridge (Boston), Mass. (November 8, 1950); Chicago, Ill. (November 27, 1950); Buffalo, N. Y. (November 28, 1950); St. Louis, Mo. (February 20, 1951); Portland, Ore. (March 8, 1951); Los Angeles, Calif. (March 16, 1951).

Another interesting address by the President entitled "Development and Trends in Light-weight Composite Construction" was given at District Meetings in Philadelphia on January 16, and in Cleveland on February 5. It is planned that this paper will be published as part of the Symposium on Structural Sandwiches to be held at the 1951 Annual Meeting.

President Markwardt also discussed "Wood as an Engineering Material" at the District Meeting in San Francisco on March 13, 1951.

As our extensive virgin forests are giving way to new forest crops throughout the nation, there is an even keener interest in the varied rôle of the forests in our national life and our national economy. In its broader sense, forestry includes not only the practice of silviculture in growing timber but also such phases as the protection of the forests from fire, disease, and insects; the functioning of the forests in modifying runoff and erosion, the province of the forest in providing recreation, and a home for the three f's—fur, fish, and fowl; and, last but not least, the use of the forest crop in providing products for our daily needs and convenience.

Every American has a stake in the efficient utilization of our natural resources. Though a renewable resource, our forest crop is no exception. It is particularly appropriate at the present time to review the rôle of forest products research in making our forest supplies go further and serve mankind better, and to appraise the significance of that phase of conservation of our forest resources that Theodore Roosevelt described as "the preservation of forests by wise use."

Technological Progress and Development

Those who have lived through the past half century have witnessed more progress and technological developments in this brief period than have obtained throughout the previous history of the world. It is as if the floodwaters of human achievement had been accumulating over the centuries back of some huge dam, awaiting the magic of an Aladdin's lamp to be released and suddenly engulf a world that had not yet attained the stature and social maturity to deal adequately with the conditions even then at hand.

This flood of progress and technological development, along with abundant natural resources, has brought the industrial revolution—the era of metals and their alloys; developments in plastics and adhesives; transportation unlimited through the automobile, the airplane, and improvements in other modes of transit; the advent of radio and television; the techniques of mass production; the profusion of all kinds of labor-saving devices; the miracle of electronics; and, as if to climax the parade, the developments in fissionable materials that herald the atomic age.

Wood and the Future

In this industrial revolution and mechanical age, with its guided missiles and push-button techniques, the question may well be asked, "What is the place of wood, one of our earliest and one of our most abundant sources of raw material? What function can wood and wood products possibly serve in a mechanical age?"

One does not need to gaze into a crystal ball to seek the answer. On every hand, and in thousands of uses, there is abundant evidence of the utility of wood itself, and of wood-base materials processed through mechanical and chemical conversion—railway ties, transmission line poles, piles, mine props, furniture, buildings, paper, rayon, photographic film, and smokeless powder, to mention but a few.

More specifically, it may be noted that there are at present more than 1000 miles of wood trestles and bridges on our eastern railroads alone; that thousands of large modern structures employing wood trusses and laminated arches have been constructed; that in the unprecedented housing program involving more than 1,000,000 homes a year, fully 75 per cent are of wood frame construction; that the consumption of fiber products has been materially increasing; that the commodities of our unprecedented production are largely packaged for shipment in wood or fiber containers; and that the products of chemical conversion are finding new and unpredictable uses and applications.

War Uses:

World War II is commonly thought of in terms of high-speed fighters and streamlined bombers, dashing torpedo boats and evasive submarines, mechanized transport and armored tanks, but to make this war machine function required a larger quantity and greater variety of wood products than ever before.

In the United States alone the annual lumber production in recent years has been on the order of 35 to 40 billion board feet. In the war years more than half of the production was assigned to the task of securely packaging war supplies for shipment to the far corners of the world.

For naval use, wood and steel rank as the two principal structural materials for building and maintaining the modern fleet. Approximately 9 million tons of steel were required by the Navy in a single war year. Wood requirements for a similar period were 3 million tons, rating wood first in volume and second in tonnage of raw materials needed for all types of naval military construction, afloat and ashore. More than 2000 vessels and 43,000 small boats were made of wood during World War II.

Paper and paper products are used in ever-increasing quantity. It is reported that in the printing of Ration Book 32 during the last war 96 carloads of paper were used, and that in the building of a battleship 100 tons of paper are required. It is estimated that the War Production Board records, if arranged in continuity, would extend 132 miles and the war records would fill the equivalent of five Pentagon buildings.

An indication of the rôle of wood in the modern war economy may be sensed from a news item in *Business Week* shortly after the start of the Korean war, as follows:

"Most businessmen are just beginning to feel the effects of the Korean crisis. But in one industry—lumber—the full

[1] President, American Society for Testing Materials; Assistant Director, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, Madison, Wis.

TABLE I.—LUMBER PRODUCTION IN THE UNITED STATES 1849 TO 1949.

Year	Total Production, million board feet	Per Capita Production, board feet	Year	Total Production, million board feet	Per Capita Production, board feet
1849.....	5 392	232	1930.....	29 358	239
1859.....	8 029	255	1935.....	22 944	180
1869.....	12 755	320	1940.....	31 159	237
1879.....	18 125	361	1941.....	36 538	...
1889.....	27 039	430	1942.....	36 332	...
1899.....	35 078	462	1943.....	34 289	...
1905.....	43 500	518	1944.....	32 938	...
1910.....	44 500	484	1945.....	28 122	...
1915.....	37 012	374	1946.....	36 382	242
1920.....	35 000	331	1947.....	35 404	236
1925.....	41 000	359	1948.....	36 807	245
			1949.....	34 257	228

force of the government's new order has already hit the market. . . . The Army wants seven times as much lumber today as it did before the shooting started. . . . Most people don't think of wood as a war material, but it is always one of the first to feel the pinch. This is particularly true in an emergency like the present one, where supplies must be shipped all over the world. Military purchases of southern pine, for example, through July of this year were double the figures for all 1949—and the end is not yet in sight."

Forest Products Industries:

Forest products, collectively, constitutes big business, largely carried on by little businesses. There are some 25,000 to 50,000 sawmills scattered all over the country that provide our lumber production. The wood products industries employ about 2 million people and produce material valued at over 10 billion dollars annually. Among the industries, in 1939, it ranked fourth in number of wage earners and sixth in value of product.

Domestic Lumber Consumption Trends:

How much less lumber is required under modern conditions than during previous periods in our history? It is interesting to observe that on a per capita basis the annual lumber consumption in the United States has, with some deviations, continued at the very high level of over 200 board feet during the past century (Table I). The 1949 per capita consumption rate of 228 board feet did not differ greatly from the 232 board feet per capita reported for 1849, a century ago.

Greatly increased consumption for the two decades from 1890 to 1910 historically marks the logging of the great white pine forests of the Lake States (Michigan, Wisconsin, Minnesota) and to some extent the pine forests of the South. These vast quantities of lumber largely went to build up the Midwest at the time of its great industrial and agricultural expansion and development.

Lumber Consumption in Different Countries:

Figures on the lumber consumption of a number of the countries of the world afford some interesting comparisons and give evidence of correlation with industrial progress and development. Highest on the list with lumber consumption of 679 and 561 cu m for each 1000 persons are Canada and the United States; intermediate with 146 and 140 are France and the United Kingdom; and very low with 7 cu m or less are Egypt, China, and India.

Requirement Trends:

The trend of this analysis shows the importance of forest products in our present economy and indicates a continuing demand for the future, aside from any consideration of wood as a potential renewable source of carbohydrate for feeding the increasing population of the world.

Of particular significance, in a world of diminishing resources, is the fact that wood is a renewable product—a crop that can be grown, harvested, and regrown much as any agricultural crop, except that the period of rotation is longer.

Importance of Research

The problem of maintaining adequate supplies of forest products has a two-fold approach—through forestry, to keep our present and potential forest land productive, and through forest products research, to improve utilization so as to make our forest supplies go further and serve mankind better. Increasing the life of railway ties from five to forty years by preservative treatment is a familiar example of the rôle of research in reducing forest drain.

Just as research was the key to the industrial revolution and is vital to its future, just so is forest products research the key to improved utilization and the development of new and improved products. Mr. T. A. Boyd of General Motors has labeled industrial research as the change-making function of modern industry—industry of every type. Illustrative of the importance of these changes is the statement of the Johns-Manville Corp. that nearly three fifths of its current sales are in products introduced since 1928 through research, and of du Pont that 46 per cent of its gross sales in 1942 consisted of products which either did not exist in 1928, or were not then made in commercial quantities.

Research Examples

At the turn of the century organized research in forest products was not yet under way, and what little there was consisted of scattered and unrelated experiments. Stimulated by the establishment of the Forest Products Laboratory in 1910, research activities have been taken up by many agencies and many industries, and Government laboratories have been started in many other countries of the world. Four decades later, forest products research has come of age and is an essential to future welfare as well as industrial progress.

Let it be repeated that research progress is not confined to the Forest Products Laboratory alone, but rather is shared by many individuals, organizations, and agencies. Often many individuals in many places over a great many years may have contributed to the solution of some problem. Credit to them should not be overlooked. Illustrative of this diverse recognition in another field is a statement by Arthur H. Compton regarding atomic energy development: "Perhaps never was the making of an important invention shared by so many persons in all parts of the world."

At mid-century, it is fitting to look back upon the progress that has been made and from the many significant

TABLE II.—CONSUMPTION OF LUMBER FOR 1946 IN 16 COUNTRIES PER 1000 POPULATION[a]

Rank	Nation	Cubic Meters per 1000 Capita[b]	Rank	Nation	Cubic Meters per 1000 Capita[b]
1....	Canada	679	9....	France	146
2....	United States	561	10....	United Kingdom	140
3....	Norway	498	11....	Japan	85
4....	Sweden	492	12....	Philippines	25
5....	New Zealand	478	13....	Indo China	11
6....	Finland	334	14....	Egypt	7
7....	Australia	320	15....	China	Very low
8....	Switzerland	294	16....	India	Very low
	World average....................155				

[a] From Table 46, per capita consumption of forest products; 1948 Year Book of Forest Products Statistics, F.A.O.
[b] 1 cu m = 35.3 cu ft.

achievements focus the spotlight on a few as illustrative of developments that have played, or may be expected to play, important rôles in "the preservation of forests by wise use."

Semichemical Pulping Process

As a start in this review of progress, let us consider one of the outstanding developments in the field of pulp and paper—the semichemical pulping process, which has resulted in a significant reduction in the 50 per cent loss of wood in the conventional chemical pulping processes.

It may be noted that, although papermaking was first invented by the Chinese about the beginning of the Christian era, the invention of a machine for the manufacture of paper took place in 1769. About 100 years ago the development of the soda and sulfite processes for the manufacture of pulp from wood took place and brought a big boom to the industry. In a single year we now require more than 19 million cords of domestic wood to meet our pulp needs.

At this point it is appropriate to bring out that our chemical processes for pulp production are very limited in efficiency. Wood fibers, like those of cotton, are composed principally of cellulose and are cemented together with a complicated and as yet too-little-known substance called lignin. Roughly, cellulose comprises about 70 per cent of the material known as wood, lignin constitutes 25 per cent, and sugars and extractives the remaining 5 per cent. If wood chips are subjected to a chemical process such as the sulfite method, the lignin cementing material is dissolved out to free the cellulose fibers that become known as pulp. The efficiency of the process, in terms of yield, is from 45 to 50 per cent.

Not only are the lignin and some of the cellulose lost, but through these by-products the sulfite pulping industry is faced with a major industrial problem, stream pollution. Marked progress is under way toward its abatement. In North America, three sulfite pulp mills now convert the hexose content of their waste liquors to ethyl alcohol. Pilot plant operations producing feed yeast from the complete sugar content of the liquors have been successfully completed, and it is expected that commerical production of yeast from sulfite liquor will soon be established. One mill recovers fuel value from the waste liquor by evaporation and burning.

For economy of operation and conservation of wood there has been an ever-present need for obtaining the highest possible yield of useful fiber from wood. The semichemical process is one of the most significant developments in line with this objective. It consists of a mild cooking process that softens the wood chips, followed by mechanical disintegration in a disk mill. It gives yields of about 75 to 85 per cent, or one half greater than the older processes, reduces the amount of stream pollution per ton of pulp, and in some instances permits the use of many woods that may not otherwise be satisfactory. By applying this 50 per cent increase in yield to the increasing quantities of pulp produced by the semichemical process, and keeping in mind the continued nature of the savings, one can get an even better appreciation of the far-reaching economic significance of this development.

The semichemical process was first developed for making corrugating board from extracted chestnut chips and was patented in 1933. From this start, the facilities for manufacturing high-quality corrugating board have greatly expanded. Up to now the semichemical method has been used for making the coarser rather than the finer grades of paper, but significant progress is being made in adapting it to both.

Extensive experiments have been conducted at the Laboratory on the semichemical pulping of many individual hardwoods (including aspen), hardwood mixtures, and softwoods, and on the use of unbleached and bleached semichemical pulps in various products. The work on the pulping process has covered the major variables of time, temperature, and cooking-liquor concentration and has included the use of both neutral and acid sulfite liquors and soda and sulfate liquors. Methods for fiberizing the partially pulped chips and refining the pulps have been developed for their use in high-quality products, including liner and specialty boards and newsprint, book, printing, writing, greaseproof, and specialty papers. Both unbleached and bleached semichemical pulps are now used for the manufacture of some of these higher-quality papers, and current interest indicates that their use is likely to expand.

To quote from a recent article in *Pulp and Paper Magazine* of Canada reporting an interview with George W. Mead, President of Consolidated Water Power and Paper Co.:

> "These new processes have a practical dollars-and-cents appeal to management because of the extremely high pulp yield and also because it has made possible the utilization of many species formerly considered weed trees, such as aspen. There is always a lag between the process development and its adaptation, even if it is a sound one. From a small beginning there are today 19 mills in the United States producing semichemical pulps of one kind or another, compared with 12 in 1947, and only 6 in 1942.
>
> "It is a virtual certainty today that the next semichemical pulp product will be glassine papers. Successful runs have been made experimentally, and one glassine producer already is laying plans for its adaptation. And don't be surprised if waxing papers, liner board, and bond papers are next."

TABLE III.—INCREASE IN SEMICHEMICAL PULP CAPACITY.[a]

Year	Number of Companies	Number of Mills	Mill Capacity, tons per day
1925...	1	1	10
1930...	2	6	355
1935...	2	6	355
1940...	...	...	460
1945...	6	10	925
1950...	13	19	2115

[a] Principal production comprises corrugating board; other products include coated magazine paper, wrapping paper, specialty board (book, match, and bottle cap), and specialty paper (magazine cover and coated card stock).

Cold Caustic Soda Process

Significant as is the "semichemical" process, there are prospects for still further increase in yield and reduction in cost by other developments. One of the most promising, still in the development stage, is the cold caustic soda process.

For the past two years, basic investigations have been conducted on the production of pulps in a high-yield range with little or no removal of lignin. This work includes studies on the kinetics of water and steam cooking and treatments with mild chemicals and little cooking. The Laboratory's new cold caustic soda process that developed from this work is an outstanding example of the results that may come from basic research. It produces pulps in yields of nearly 90 per cent by a mild treatment of chips at atmospheric temperature and pressure with caustic soda solution, followed by mechanical fiberization of the treated chip. The process was tried commercially in a Wisconsin pulp mill on aspen chips, and the pulp produced was made into corrugating board with unusual success for the first trial. The corrugating board and the finished fiberboard compared favorably with commercial boards of this grade.

This process has the advantages of high yield, low chemical cost, and cheap and simple treating equipment, and does not require steam. The yields of nearly 90 per cent are somewhat higher than those obtained by the semichemical method. All indications point to this process as one of basic and far-reaching importance. These developments in

pulp and paper fulfill ideally the basic objective of making our forest supplies go farther and serve mankind better.

Wood Sugar from Wood Waste

One of the most important and ever-present problems in wood utilization is that relating to the useful employment of what is commonly known as waste. Much progress has been made, but in the forest industries there are yet vast quantities of material in one form or another that have not as yet found diversion to their highest possible use. In the regular sawmill operation only one third of the tree is converted to lumber. Of the forest drain from various types of cutting operations, estimated at 183 million tons per year, about 93 million tons, or about 50 per cent, are used for the purpose cut; about one sixth for other than the purposes cut; and about one third, or 60 million tons, remains unused. This unused wood, on a tonnage basis, is somewhat comparable with the actual drain of iron and steel and far exceeds that of some of the other metals, such as copper and aluminum.

There is under way one development for the utilization of wood waste that offers great promise for the future, namely, the production of sugar from wood waste by a process that has been developing for 100 years. Substantial improvements in the process have been made over the past five years, with the result that it is now on the verge of industrial success.

By continuously passing a weak water solution of acid through a bed of wood chips for a few hours at high temperature and pressure, the cellulose and hemicellulose, amounting to some 50 to 70 per cent of the wood substance, are converted to sugars. The yield of sugars varies with the kind and quality of the wood, but, on the average, 1 lb of dry wood will produce about $\frac{1}{2}$ lb of sugars. If the sugar solution is evaporated to a molasses containing 50 per cent of sugar, the yield is approximately 1 ton of molasses from 1 ton of dry wood.

The sugars have a great variety of potential uses. For example, wood molasses can be used as part of the feed ration for cattle, sheep, hogs, and poultry—a number of agricultural experiment stations throughout the country have been experimenting with it for that purpose—or the crude sugar solution can be fermented to alcohol without first being evaporated to molasses consistency. Another possibility for the sugar is in the production of yeast for animal feeding, or even for human use. Also there are numerous possibilities of producing various industrial chemicals from the sugar, either by direct chemical processing or indirectly through the use of fermentation organisms. The further the work on the problems of converting wood into sugar advances, the more apparent it becomes that waste and low-grade wood offer increasing promise of becoming the raw material for a group of chemical industries of great national importance in peacetime, and even more so in time of war.

Historical Background:

As mentioned, the conversion of cellulose to sugars by hydrolysis has been known and studied for over 100 years. The accumulated information was first put to commercial use in 1913 when a plant was built to hydrolyze Southern Pine mill waste at Georgetown, S. C., using the so-called American process in which wood was hydrolyzed in a rotary steam-heated digester. Yields up to 25 per cent were obtained by a single digestion. This plant, and a second at Fullerton, La., operated successfully until 1923.

Continued research, concentrated mostly in Germany, finally led to the German Scholler process in which multiple digestions were carried out with dilute sulfuric acid in tall stationary digesters. Yields of 40 to 50 per cent of sugar were obtained in concentrations of 3 to 3.5 per cent in 18 to 24 hr. Several plants in Germany produced wood sugar for alcohol fermentation all through World War II.

The Bergius process, another German process developed at about the same time, uses concentrated hydrochloric acid as the hydrolytic agent in special acid-resistant equipment. Although this process gives a cleaner sugar solution from which dextrose can be more readily crystallized in somewhat higher yields, it is necessary to recover the acid for reuse, which makes the process expensive.

A means of hydrolyzing wood with sulfurous acid has been developed in Finland through the pilot-plant stage for the production of crystalline dextrose.

Madison Wood Sugar Process:

Work on the hydrolysis of wood to sugar was revived at the Forest Products Laboratory during World War II. A pilot plant built for working out operating details of the Scholler process was used in studying a broad range of hydrolysis conditions. It was shown that, under the Scholler operating condition, the carbohydrates were almost completely converted to sugars but the product was subjected to high temperature for so long a time that much of the sugar was decomposed. This information led to the development of the Madison Wood-Sugar Process, which employs continuous percolation to decrease the time during which the sugar formed is subjected to acid and heat. As a result, higher yields of undecomposed sugar and higher sugar concentrations are produced in 4 hr than were obtained in 18 hr with the Scholler procedure.

By stopping the percolation when the final sugar concentration falls below 1 per cent, it is possible to obtain average sugar concentration of from 4.0 to 5 per cent in yields of 45 to 55 per cent from bark-free woods on an oven-dry weight basis. Bark may be included with the wood, but decreases the yield materially.

The acid in the sugar solution is neutralized with lime, and the insoluble precipitate of calcium sulfate is filtered off. The neutral sugar solution is then evaporated to a molasses containing approximately 50 per cent of sugar by concentrating it tenfold.

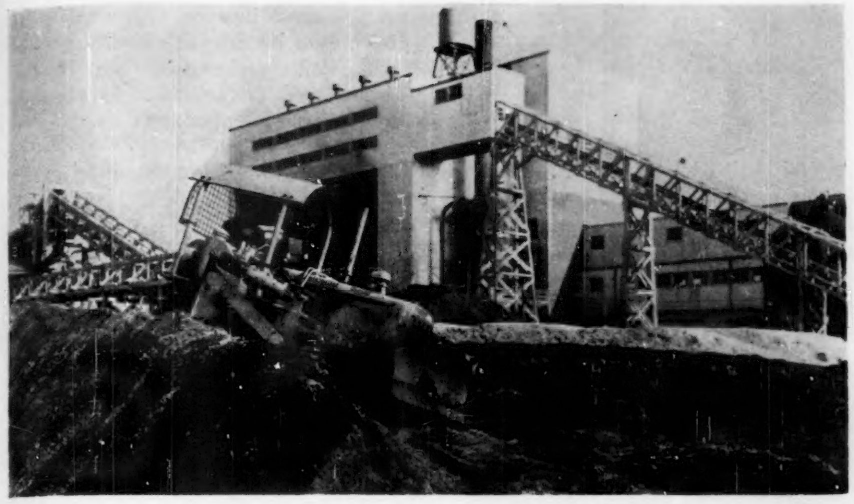
Extensive feeding tests during the past two years have shown that wood sugar molasses is an excellent animal food. Cattle and dairy cows like it and have shown excellent gains in weight and milk production when fed 3 to 6 lb per day per head. It has been successfully used as a binder in pelleted foods and as a preservative for silage. In all of these applications it has proved to be equivalent to blackstrap molasses.

Yeast from Wood Sugar:

Food yeast that is high in protein and vitamin and suitable for human or animal consumption may be produced rapidly and in good yields from the sugar obtained by wood hydrolysis. Dilute wood-sugar solution to which is added ammonia or other inorganic nitrogen, phosphate, and potassium salts, is fed continuously into a yeast propagator where air is supplied. The yeast flows continuously with the spent solution from the propagator, is recovered and washed in a yeast separator, and is dried on a drum drier. The yield of yeast is 40 to 50 per cent of the sugar in solution, or 20 to 25 per cent of the wood from which the sugar was made. This yeast contains 46 to 56 per cent of protein, 2 to 7 per cent of fat, and 6 to 12 per cent of ash. Feeding tests indicate that this yeast is high in B-complex vitamins.

Commercial Status:

The various processes in the production of wood sugar have been carried on extensively in pilot-plant operations. A large plant was built in Oregon during the war for that purpose but never got into successful commercial operation. It is expected that this plant will



Commercial and Demonstration Plant at Springfield, Oregon, for production of molasses and alcohol from wood residue. Note stockpile of wood residue in foreground.

start production again in the near future with greater hope of success.

The production of wood sugar from wood waste is particularly encouraging because nearly any type of wood waste is suitable. The amount of molasses obtainable depends on the amount of cellulose in the wood. Sawdust, slabs, shavings, woodworking mill waste, woods waste, culled trees, and wood residues from which rosin has been extracted have been successfully tested for production of sugar. Also, it is possible to use wood with a high moisture content when correction for the water present is made by adding to the initial acid.

The wood sugar process is another important development that has great promise of making our forest supplies go further and serve mankind better.

It is not surprising that the implications of the wood sugar process have inspired some pens to verse. After a report on the feeding experiments before a meeting of the American Chemical Society, Richard Armour summarizes the potentialities in other than a serious vein, as follows:

"Go hustle up some redwood
  And fetch a bit of pine,
Cattle now are fed on wood,
  And so, it seems, are swine.

"The sawmill's busy whirring
  Turns out, with every gash,
The stuff that, with some stirring,
  Makes very yummy mash.

"Here's Bossie, better feed her.
  She's had a busy day.
Fill up her bin with cedar,
  She'll never miss her hay.

"And here a hen comes clucking,
  Here waddles up a goose.
So start your mealtime chucking
  Of tasty bits of spruce.

"Rejoice, you farmer fellows,
  And praise the chemist's brain.
In lofts the sawdust mellows
  For all the world like grain.

"No lack of food this winter
  For fattening the stock.
There'll always be a splinter,
  A chip from off the block.

"Give thanks to mental giants
  Who've done what seemed incredible.
God made the tree, but science
  At last has made it edible!"

Improved Saw—The FPL Duo-Kerf

Turning from the field of chemical to mechanical conversion, there has recently been announced a new development of great promise—an improved type of sawtooth known as the FPL Duo-Kerf.

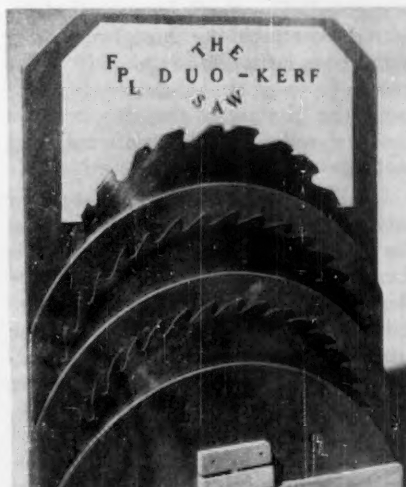
Since the first circular saw was put into use, more than 150 years ago, there have been until fairly recently only a few outstanding developments, such as the inserted-point and the band saw. Many good ideas were advanced that were fundamentally sound but could not be applied at that time. Lack of adequate fabricating methods, materials, and machines to make or use the improvement handicapped the developments, and in other instances the economic conditions did not as yet invite a change. For example, the use of hard teeth to obtain reduced maintenance depended on the development of abrasive wheels and grinding machines to facilitate sharpening; thin saws capable of reducing saw-kerf waste were troublesome in service, and in the days of cheap logs resulted in greater maintenance and interruption costs than could be offset by the material savings effected; and when material was cheap, the allowances for dressing could be generous, so that precision sawing had no profit inducement to offer.

Now, however, improved materials and superior machine designs are available, and the economic pressure of expensive wood and labor and stiff competition invites any developments that will conserve material or labor, or aid in maintaining quality or continuity of production.

In the last decade or so, there have been numerous new features, such as tungsten carbide, high-speed steel, hardcoated sawteeth for circular saws, the buttress tooth and the silver tooth on band saws, the Ferrari smooth-sawing tooth form, the Big Four's thick-hub tensionless circular saws, the Grupp cut-control safety saw, the hubless Sally saw, the Cox chipper tooth for chain saws, and others.

And now a basic research study on the mechanism of sawing has led to the development of the Duo-Kerf principle of rip sawing, recently announced by the Forest Products Laboratory. Duo-Kerf offers a reduction in kerf, reduced power requirements, greater accuracy of cutting, and smoother surfaces. It can be applied to circular and band saws and to sash saws for the ripping of either green or dry material.

"Duo-Kerf" is a name descriptive of the sawing process involved. Briefly, the Duo-Kerf saw uses two types of teeth, arranged alternately. The first of each pair is the "chipper" tooth, an ordinary chisel tooth with little or no swage. It cuts a *narrow* saw kerf of



At the top is a preferred form of the FPL Duo-Kerf saw, with alternating chipper and side dresser teeth, as compared with conventional circular saws at bottom. Center is a conventional saw converted to Duo-Kerf. Saw cuts in block (*below*) show thinner kerf (*right*) of Duo-Kerf saw. Ripped brands below show smoother cut of Duo-Kerf.

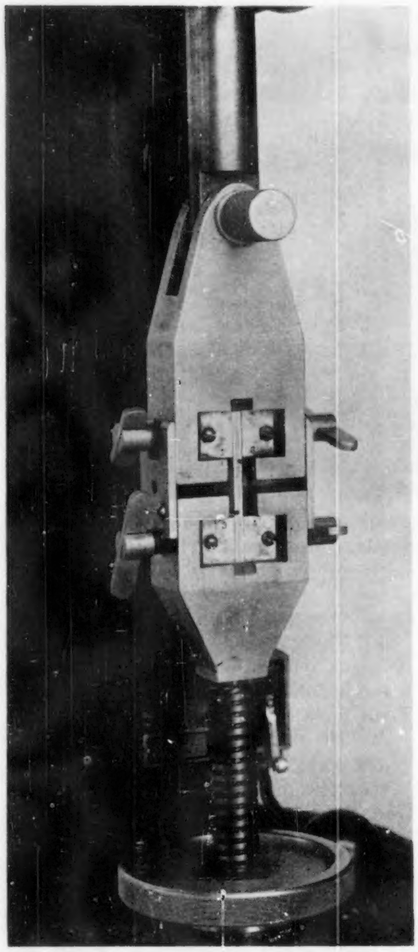
the ordinary type, but this is immediately widened by dressing both kerf surfaces with the second tooth of the pair. This second tooth, the "side dresser," is set a trifle low in the blade so that its top does no cutting. The light dressing cut is made by the parallel sides of the side-dresser, forming the slightly wider second kerf that is distinctive of the double—or Duo-Kerf—system.

To obtain information on cutting actions in the basic research study, a pendulum dynamometer was designed and built at the Laboratory for measuring the power consumed in cutting wood with various types of tools. This dynamometer is extremely flexible in application, and practically any type of cutting action, direction of grain, and speed can be handled.

In studying the action of the chisel-type sawtooth in ripping, four forces were found in operation. First is that which is required to sever the fibers at the bottom of the chip being removed. This force is the same whether the chip is thick or thin and changes only with tool sharpness, while the other forces are proportional to chip thickness. The second force is that required to free the sides of the chip from the kerf walls, by a shearing or splitting action that sometimes runs into the stock (with cross grain) and causes the tear-cuts. The third force is that required to crumble the chips, by shearing along lines crosswise of the chip. The fourth force is that required to overcome the binding of the chip between the kerf walls and the frictional drag met in removing the chip or sawdust.

It is largely in this last step that power savings are obtainable. By discharging the chip into a wider space as soon as it is sheared free, the binding action of the chip and the drag on the kerf walls are reduced, while the smoothness of the kerf surfaces further reduces the friction. An occasional additional saving occurs in ripping cross-grained material, since oblique splitting along the edges of the chip runs into the widened kerf instead of running into the stock. Thus buckling and tearing loose of some of the fibers is avoided.

The technical specifications for Duo-Kerf fitting are not fully worked out as yet, since the many possible variants have to be production-line tested. A converted inserted-point circular head-saw has been tested on a portable mill, and several forms of converted and redesigned bench saw blades have been tested. The pendulum dynamometer has been used, of course, to work out some details. Much still needs to be done, but the cooperation of several commercial firms has been promised.



Details of test specimen and grips for conducting plywood glue shear test for evaluating strength of bond. (ASTM Designation D 805 - 47)

The results so far indicate that species differences have little effect on Duo-Kerf performance, although green and dry material may require different ratios between initial and final kerf, or in hook angle of the side-dressers.

The kerf reduction that Duo-Kerf permits results in a significant saving in view of high material costs. The reduction in power requirements should be a boon to underpowered small mills by permitting increased production, and to operators who want the greater sawing accuracy resulting from an easier-running saw, assurring better control of quality and reduced dressing allowance. The smoother surfaces should enhance the appearance and marketability of unfinished lumber, and, in some instances, permit omitting a dressing operation in re-manufacture. It is, of course, too much to expect that all these advantages can be enjoyed to the full simultaneously. Quality control, type of product, operating methods, and cost balances will dictate, to some extent, how completely the Duo-Kerf advantages can be enjoyed.

Here again is an example of a development—a new one—that has great possibilities, which if successfully applied should contribute its share to the job of making our forest supplies go further and serve mankind better.

Glues and Gluing Techniques

Perhaps no single factor has been responsible for such significant and timely advances in the field of modern wood construction as the development in glues and gluing techniques. And perhaps there is no better example of a development that involved the participation of so many—chemical industries, wood industries, and research laboratories—than that which has occurred, and is still occurring, in the glue field. Synthetic resins are now available that have greatly enlarged the horizon for glued products that must resist continued exposure to adverse moisture changes. Some of the synthetic resins developed are also remarkably effective in retaining bond strength under exceedingly low and under relatively high temperatures (−70 to 400 F.) when used in metal-to-metal bonds.

Among the older adhesives available were starch glues, animal glue, soybean glues, casein glue, and blood glue, the latter three being water-resistant. Research on glues has been centered around the study of the conditions essential to secure a good glued joint with all glues when used with different woods and the evaluation of the serviceableness or durability of glued joints by various means, taking into account different exposures and exposure cycles, and temperature and moisture variations.

Synthetic-Resin Glues:

The best-known and most commonly used of the newer synthetic-resin glues for woodworking are the phenol-formaldehyde and urea-formaldehyde types. There are also some synthetic-resin adhesives of the resorcinol-formaldehyde, melamine-formaldehyde, and polyvinyl-resin emulsion types. Since "formaldehyde" is common to most of these synthetic resins, this term is usually left off in describing them. When properly applied and cured, joints made with synthetic-resin glues of the phenol-, melamine-, or resorcinol-resin type are highly resistant to severe conditions of service.

The phenol, melamine, resorcinol, and urea resins may be combined with each other, with other resins, or with other chemicals to form glues of somewhat different basic characteristics than those made from either resin alone. For example, phenols are often combined with resorcinol resins, and urea resins with melamine resins. The phen-

ols are also combined with blood albumin, walnut-shell flour, and finely divided cellulose fiber, and the ureas with cereal flour, walnut-shell flour, or other materials. As a result of this practice there are resin glues with varying amounts of other materials, some of which are variously referred to as "fortified," "modified," and "extended."

Synthetic-resin glues may be classified as thermosetting or thermoplastic. The phenol, urea, resorcinol, and melamine resins belong to the thermosetting class, and once the condensation reaction, which is hastened by heating, is complete, no subsequent softening occurs even though the temperature is increased beyond the original setting temperature. Synthetic resins of the thermoplastic class, such as the vinylacetate or butyrate, soften whenever the temperature is raised above the softening range that is characteristic of each particular type of resin.

Form of Glue and Setting Requirements:

Synthetic-resin glues may be marketed in the form of a dry film, dry powder, suspension in water, or nonaqueous solution. A number of them are formulated for hot pressing, during which the high temperatures soften the resin to an adhesive condition and complete the setting reaction. Room-temperature-setting resins now in common use are mainly of the urea-resin type and contain a catalyst that accelerates the chemical reaction and results in the setting of the glue at ordinary room temperatures. Resorcinol-resin adhesives can be used at room temperatures to produce, without hot pressing, bonds of high durability.

With the advent of synthetic-resin glues, it must not be concluded that the older types are obsolete. There are still uses for casein, soybean, starch, animal, and other glues.

The right glue for the right job must, of course, be selected, but this is not the only detail that must be considered to insure good joints. It is highly important also that the numerous details involved in what may be termed fabricating technique be properly controlled. These include careful preparation of the wood, both with respect to moisture content, uniformity of thick ness, and surface condition, suitable equipment for spreading glue and applying glue pressure, and proper temperature conditions, as well as technical knowledge and skill.

Despite these substantial developments of adhesives, further developments are looked for. In addition to their use with wood, adhesives are the key to sandwich construction, which will be discussed later, and sandwich construction is only now in its infancy. For aircraft, for guided missiles, for other special applications, in fact for all uses, there is need for glues with as yet unheard-of requirements—glues that will set at any temperature, even outdoors in cold weather, glues of a contact type and that require no pressure in setting, glues with indefinite working lift in assembly, glues that are water- and vapor-proof, and glues that are not affected by high or low temperature—notably the elevated temperatures obtained in supersonic flight or the arctic temperatures in the deep subzero range.

Glued Laminated Construction

While glued laminated construction had its origin in Europe some decades ago, its advent in the United States directed attention of architects and engineers to a new product admirably adapted to a wide variety of building and construction uses and in effect launched a new industry. Factors that favored the ready acceptance of laminated construction, aside from its unlimited architectural possibilities, were the significant improvements in water-resistant and waterproof glues and the development through research of the necessary engineering design data.

The term "glued laminated construction" is applied to structural members glued up from smaller pieces of wood, either straight or in curved form, with the grain of all the laminations in the direction of the length of the member. It is thus basically different from plywood in which the grain direction of adjacent plies is usually at right angles. The laminations may be of any thickness or length, of narrow pieces glued edge to edge to make wide ones, of the same or different wood species, or of pieces bent to curved form during gluing—all of which afford infinite choice in design, subject only to economic factors involved in production and use.

The first research centered around the development of engineering design data for glued-laminated arches. It included tests of structural units to check such factors as design formulas and working stresses and the effect on strength of curvature, scarf joints, and the presence of knots in the inner laminations. The results of this research were presented in U. S. Department of Agriculture *Technical Bulletin No. 691*, "The Glued Laminated Wooden Arch," which provided the technical data necessary for use of laminated arches on a sound engineering basis.

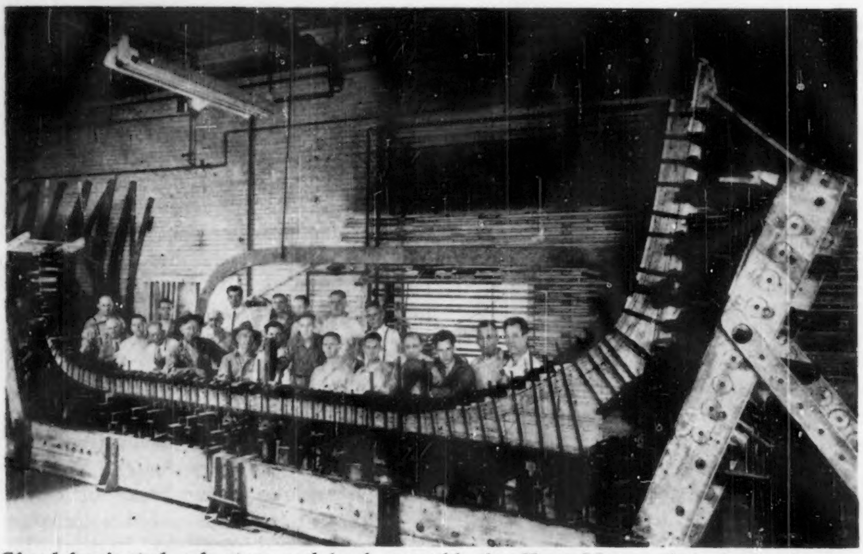
As the possibilities of glued laminated construction were further developed to include beams and other structural elements, additional studies were made.

Among the significant features of glued laminated wood construction are the following:

1. Ease of fabricating large structural elements from standard commercial sizes of lumber. Laminated arches have already been erected that provide buildings with clear spans up to 170 ft and arches with sections as deep as 7 ft have been projected.
2. Achievement of excellent architectural effects and the possibility of individualistic interior decorative styling.
3. Freedom from checks or other seasoning defects associated with large one-piece wood members, in that the laminations are thin enough to be readily seasoned before fabrication.
4. The possibility of designing on the basis of the strength of seasoned wood, for dry service conditions, inasmuch as the individual laminations can be dried to provide members thoroughly seasoned throughout.
5. The opportunity to design structural elements that vary in cross-section along their length in accordance with strength requirements.
6. The possible use of lower-grade material for less highly stressed laminations, without adversely affecting the structural integrity of the member.
7. The fabrication of large laminated structural members from smaller pieces is increasingly adaptable to our future timber economy, when more of our lumber will come in smaller sizes and lower grades from smaller trees.

On the other hand, there appear to be no disadvantages of laminated construction as such. Modern glues and gluing techniques provide both adequate and effective means of bonding laminations into an assembly equal or superior in strength to a single-piece member of equivalent section. Glues may be selected to provide a laminated assembly that is water-resistant or waterproof as conditions of use may dictate. When properly glued, laminated members may be given preservative treatment by pressure methods much as solid timbers are treated, thereby having greater resistance to decay when used under adverse exposure conditions.

Glued laminated wood can be used in a wide variety of structures, such as buildings, bridges, aircraft, and boats. Its versatility is enhanced by the fact that it can be made to required forms and sizes without regard to standard sizes and shapes and is free of the limitations commonly imposed on timber



Glued laminated oak stem and keel assembly for Navy Motor whale boat, showing clamps employed to provide pressure during curing of glue.

structures by the sizes and lengths of available solid material. While large structures are generally laminated from material in lumber thicknesses, it has been found that laminating with veneer gives comparable results.

Laminated Ship Timbers:

An outstanding development in glued wood was worked out during World War II through the combined efforts of glue producers, a manufacturer of glued wood products, the War Production Board, the U. S. Navy, and the Forest Products Laboratory. That was the production of heavy, curved ship timbers by gluing thin lumber together over a curved form. With the new glues available and the techniques worked out in those experiments it became possible to produce the large, heavy keels, frames, skegs, and other parts in full length, curved to exact shape, and without loss from breakage. There was not enough suitable oak available in the sizes required to produce all these timbers by bending full-size pieces to shape. Furthermore, the loss by breakage would have been prohibitive. The laminated keel-stem assemblies, in addition to their other salutary features, were much superior in strength and stiffness to the conventional keel-stem assemblies of wood with bolted scarf joints. Here was an example of direct and successful co-operation between Government and industry that resulted in mutual advantage through industrial progress.

Laminated Bridge Timbers:

To determine the practicability of laminated construction for large structural timbers subjected to heavy loads, a number of experimental installations of laminated railway bridge timbers have been made in different parts of the country. The timbers are bonded with phenol-type adhesives to afford moisture resistance and are treated with creosote after laminating to provide resistance to decay. Other bridge installations have been made with laminated arches. These several installations are being inspected periodically to obtain information on their performance.

The development of glued laminated construction is an example of research that has paid off in the establishment of a new industry, an industry that already has a number of fabricating plants in different parts of the country, and that contributes to our economic welfare. Through the more efficient and economical use of wood, the development of glued laminated construction makes an important contribution to the job of making our forest supplies go further and serve mankind better.

Sandwich Construction

When John Montagu, fourth Earl of Sandwich, as a timesaver for his gambling propensities, invented that delectable meat and bread combination that later became so popular, little did he realize that it would one day bear his name. And much less did he ever suspect that the name "sandwich" would be given to another combination of materials of the nonedible variety, or that the ASTM would one day have a technical committee on Structural Sandwich Constructions.

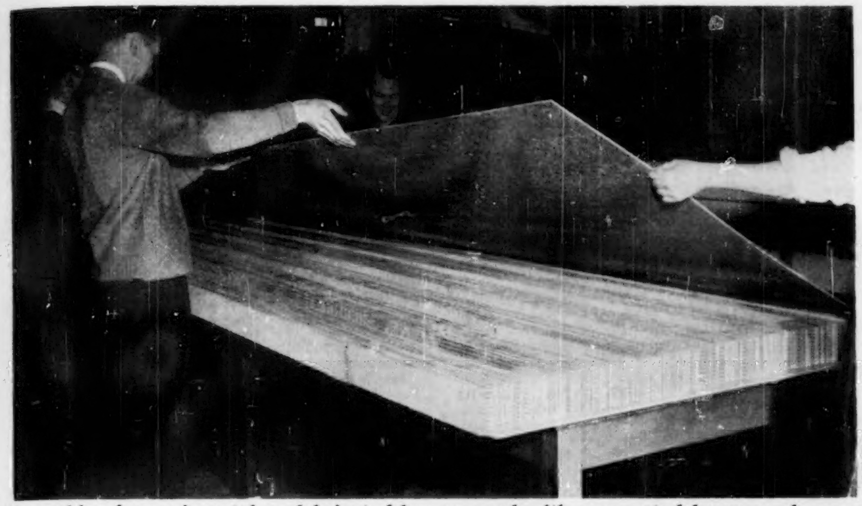
What is a structural sandwich? A great deal of thought by scores of people has been given to the development of a definition, which though probably not perfect, affords a broad concept of specific constructions concerned, as follows:

"A construction comprising a combination of alternating dissimilar simple or composite materials assembled and intimately fixed in relation to each other so as to use the properties of each to specific structural advantages for the whole assembly."

As with laminated wood construction, the great improvements in adhesives have opened unlimited opportunity for sandwich construction to provide rigid lightweight components or products of not yet fully realized possibilities. Available as well as essential also for this development are a great variety of materials suitable for facings and cores, and the results of research to provide the necessary design criteria. Among materials are wood, plywood, modified wood, fiber products, metals, and glass cloth for facings; and fiberboard, wood, honeycomb materials, expanded rubber, cellulose acetate, and other lightweight materials for cores. The possibility of bonding these materials in unlimited combinations enables the designer to employ a sandwich construction to take advantage of the particular properties of each material and use it in its most efficient form.

One of the early types of sandwich construction used was the combination of metal facings over a plywood core. Already well known is the success obtained with sandwich construction technique in the all-wood Mosquito bomber by de Haviland in which birch plywood facings were glued to a low-density balsa wood core to afford a lightweight construction of considerable thickness and of relatively high strength and stiffness. Metal-covered balsa, comprising aluminum facings bonded to an end-grain balsa core, is being currently employed in aircraft design. Service reports have been encouraging. Still another type of sandwich consists of a cellular honeycomb core made of any one of a variety of sheet materials, with facings of plywood, metal, glass cloth, or other materials. Low cost, lightness, and excellent strength and stiffness are attained. Much developmental work is under way on applications of this type of sandwich. Paper impregnated with resin to increase strength and water resistance is promising for the cellular core material. Other materials, such as glass cloth and metal foil, may also be used for cellular cores.

Present and potential uses for sandwich construction include radomes, airplane fuselages and wings, airplane flooring, doors, bulkheads, ailerons, and flaps; walls, ceilings, and partitions in railway cars; hatches, partitions, and bulkheads in boats; and doors, frames, wall panels, and floor panels in houses.



Assembly of experimental prefabricated house panel with corrugated honeycomb paper core and plywood facings.

The increased use of sandwich construction is dependent on the availability of adequate design data. Extended research has been under way to determine the properties of various facing and core materials and to develop formulas, theoretical and empirical, to translate the mechanical properties of each component material in terms of the behavior of the sandwich, under various types of load and support conditions.

Formulas for plywood panels are already available. Impetus was given to the development of these formulas during World War II in connection with wood aircraft, but they are applicable not only to aircraft but to any structure built of wood and plywood. These formulas could also be applied to other sandwich constructions were it not for the low strength and elastic properties of the core material, which make necessary the consideration of additional deflections due to shear strains in the core and of the shear strength of the core material. The inclusion of these effects is the main theoretical difficulty in the establishment of valid design formulas. The problem is exceedingly complicated for curved plates and shells of double curvature. Investigations have been undertaken on some phases of this work, but much remains to be done to provide the complete complement of design criteria needed to take full advantage of the possibilities of sandwich construction.

It is obvious that it costs money to transport excess weight, and it would appear that the transport industries should be among the first to take advantage of the possibilities of sandwich construction. Naturally, the aircraft industry was among the first to explore and develop structural sandwich applications and the principles of stressed-skin construction. The de Haviland Mosquito bomber, previously mentioned, is a good example of early World War II sandwich design, affording lightweight thick shells with smooth exteriors. The metalite construction consisting of an aluminum facing over a balsa wood core, developed by Chance Vought, is another modern example. And now comes word that sandwich construction has reached the freight-car field.

Just recently Pressed Steel Car Co. unveiled its "Unicel" car as its concept of modern freight-car design. The car is made mostly of plywood bonded and shaped with electronic high-frequency heat and special synthetic resins. In the new car the entire structure becomes in effect a center sill, through the stressed-skin principle of monocoque design. In the design, advantage was taken of the latest design data on plywood construction. The car is practically all wood. The trucks and drawbars are of steel, of course, as are the door frames. The remainder of the car is a continuous solid piece of wood and plywood glued together. There is not even a nail.

The new freight car is 50 ft long and has a carrying capacity of 110,000 lb. The trucks bear against steel plates mounted directly on the wood, and the coupling bars are embedded in the wood. Thus the wood takes the drawbar pull and also the impact when two cars are coupled together. The new freight car has just passed the pilot stage. When loaded to capacity it deflected only 0.09 in. at its center. When a similarly loaded conventional boxcar was bumped against it in switching tests, it was reported that the new car exhibited considerably more impact resistance and stiffness than the conventional car. Advantages claimed are reduced weight, increased strength, fewer man-hours and less skilled craftsmen needed to build it, reduced cost, and increased capacity.

Other Research Developments

In this brief review it has been possible to mention but a few of the many things that research has accomplished that are of definite value to the country. Other developments in part include:

Shipping containers.—Improvements reducing shipping space, cost, and damage to contents with resultant savings of millions of dollars.

Housing research.—The "stressed skin" principle employed in most prefabricated construction—the development of vapor barriers and condensation control methods.

Seasoning.—Internal-fan dry kiln, of which more than 5000 are now in use.

Fire-retardant lumber treatments:—More than 40 million board feet of lumber were treated during the war.

Working stresses for timber design.

Modified woods and wood-base materials.

Fields of Needed Research

With due recognition of what has already been accomplished in forest products research, there are still innumerable problems to be undertaken, and the possibilities of far-reaching results are unlimited. A few of the major problems include finding ways and means of utilizing a greater portion of the tree—only about one third of the standing tree is now converted into lumber; solving the enigma of lignin, which comprises 25 to 30 per cent of the wood substance, and developing for it profitable markets; modifying the hygroscopic properties of wood and improving its dimensional stability; developing simpler, less expensive, and more efficient processes for chemical conversion; improving harvesting and fabricating equipment and techniques; developing non-destructive tests for close evaluation of the strength and stiffness of structural timbers containing knots and other natural characteristics; developing more rapid seasoning techniques without impairment of the properties; developing improved log grades; and developing more effective fire-retardant methods and treatments.

Wood for the Future

In addition to the many uses for wood, it must not be overlooked that wood is a crop and that this crop is a potential source of carbohydrate that

TABLE I.—USE CHARACTERISTICS OF LAMINATING GLUES.[a]

Glue Type	Exposure Suited for	Storage Life at 80 F., months	Working Life at 70 to 75 F., hr	Maximum Permissible Assembly Time at 70 F., min		Permissible Moisture Content of Wood, per cent		Setting Characteristics			Laminating Pressure, psi		Conditioning Period,[b] days
				Open	Closed	Minimum	Maximum	Cold	Room Temperature	Intermediate Temperature	Minimum	Maximum	
Casein	Normal interior	12	5	15	30	2	18	Yes	Yes	Yes	100	250	5-7
Urea, powdered with catalyst	Normal interior	12	2-6	10	20	7	15	No	Yes	Yes	100	250	5-7
Intermediate-temperature-setting phenol	Interior and exterior	2-6	2-8	30-60	60-120	6	17	No	No (except with some low-density species)	Yes	100	250	1
Resorcinol	Interior and exterior	12 or more	2-5	15	50	6	17	No (except with low-density species)	Yes	Yes	100	250	1-7
Melamine[c]	Interior and exterior	6-18	2-36	30-60	60-120	7	15	No	No	Yes	100	250	1

[a] The values given in this table are approximations.
[b] Where glue is completely cured by application of heat accompanied by adequate humidification before pressure is removed, merely cooling to room temperature is sufficient; where no heat is applied, a 5 to 7-day conditioning period is desirable.
[c] Includes glues both with and without separate catalyst.

can be turned to the task of feeding the world's population, if and when additional food sources are essential. Even by presently available methods, one-quarter ton of yeast with a protein content of 50 per cent can be obtained from 1 ton of dry wood. When it is considered that only a few of the many species of microorganisms have ever been grown for such purposes, the possibilities of further research in this field are striking.

The chemical industries can be expected to play an increasingly greater rôle in the conversion and utilization of wood in its service to mankind. However, it does not appear that efficient complete wood chemical industries are likely to be developed as units by themselves, but rather will be geared to the forest and to such other wood industries as may be found suitable to the kinds and qualities of wood that the forest grows. This is the pattern known as integrated utilization, which in conjunction with forest harvesting on a sustained yield basis insures permanent and efficient, but not necessarily static, industries.

And what of the future of our forests? Says Dr. J. A. Hall, former Director of the Pacific Northwest Forest and Range Experiment Station, and now Director of the Forest Products Laboratory, in a paper before the American Association for the Advancement of Science:

"Diversified utilization of the forest crop can be expected to encourage intensive management of the forest. As long as the sun shines and the rains fall there need be no shortage of wood in the world if we manage the forest well and learn to use the tools of industry, products of our industrial civilization, for the more nearly complete employment of wood in meeting human needs. And, above all, the land that grows the forest is land that usually cannot be put to other profitable use. The forest resource is unique in that its proper harvesting is the best means possible of ensuring a permanent forest resource."

And is not this, after all, but another way of expressing the philosophy of Theodore Roosevelt as referred to earlier in the introduction:

"Forestry is the preservation of forests by wise use."

Acknowledgment:

Acknowledgment is made to various staff members of the Forest Products Laboratory for assistance and material used in the preparation of this manuscript.

Thermal Properties of Certain Laminated Plastics

By E. M. Schoenborn,[1] A. A. Armstrong, Jr.,[1] and K. O. Beatty, Jr.[1]

THE initial rate of decomposition of a plastic when exposed to an elevated temperature depends on the thermal diffusivity and conductivity as well as on the chemical constitution of the material. Where the time of exposure is limited or where the specimen is thick, these thermal properties are of increased significance. For this reason, measurements of diffusivity, conductivity, and heat capacity were carried out to parallel the work done in a recent extended investigation (5)[2] of the thermal stability of laminated plastic materials.

The variety of plastic laminates available is quite large, and is augmented by the differences in properties from batch to batch and even from piece to piece of a single type of material. It is therefore apparent that extreme precision in measurement has little significance, and appropriate methods should combine reasonable accuracy with simple, rapid procedure. Unsteady-state heat transfer measurements seem inherently suited to these requirements but investigation of the literature reveals that of the three properties—diffusivity, thermal conductivity, and heat capacity—only the first has an unsteady-state procedure as the established method of measurement. Further study revealed the possibility of using similar methods for the other two measurements and these were subsequently adopted.

Scope of the Investigation.—The work reported here covers the measurement by unsteady-state methods of the thermal diffusivity, conductivity, and heat capacity of eight different types of plastics in nominal thicknesses of $\frac{1}{8}$ and $\frac{1}{2}$ in. In four cases similar products of two different manufacturers were tested. A list of materials and a general description are given in Table I.

In addition to the unsteady-state procedure, heat capacity was measured by a dry calorimeter method, thus providing independent check on consistency of results.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Department of Chemical Engineering, North Carolina State College, Raleigh, N. C.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

TABLE I.—PLASTIC MATERIALS TESTED.

Type[a]	Manufacturer	Description	Resin Content, per cent
PBE...........	A	Paper-base phenolic	50.0
PBE...........	B	Paper-base phenolic	57.5
FBG...........	A	Cotton fabric-base phenolic	50.0
FBG...........	B	Cotton fabric-base phenolic	57.5
GBE...........	B	Glass mat-base phenol aniline	59.5
GMG...........	A	Fiberglas-base melamine	40.0
GMG...........	C	Fiberglas-base melamine	45.0
LPP*..........	D	Fiberglas-base low-pressure phenolic	28.4
Poly*.........	D	Fiberglas-base low-pressure polyester	31.0
GSG...........	E	Glass-base silicone	52.0
GSG...........	F	Glass-base silicone	40.0
MCTFE*.......	..	Monochlorotrifluoroethylene	...

[a] Types given are Navy designations except those followed by an asterisk.

Theory

Thermal Diffusivity Measurement:

The basic relationships for unidirectional heat transfer in the unsteady state are given by Eq 1.

$$\frac{\partial t}{\partial \theta} = \alpha \frac{\partial^2 t}{\partial x^2} \qquad (1)$$

where.

$$\alpha = \frac{k}{\rho c} \qquad (2)$$

and is known as the thermal diffusivity.[3] The value of the diffusivity can be determined by any of a number of temperature-time-distance measurements and a number have been worked out and used (**2**, **4**). One of the most convenient methods is to measure the midplane temperature of a slab of material being heated simultaneously through its two faces while the edges are completely insulated. These conditions may be achieved by an apparatus such as that shown diagrammatically in Fig. 1. A midplane is achieved by taking two layers of plastic. Drilling of a thermocouple hole in the center of a single layer also would be satisfactory though more difficult.

If the initial temperature of a sample of thickness L is uniform at t_0, and the faces are suddenly raised and maintained at the constant elevated temperature T_0, it may be shown that the solution of Eq 1 is an infinite series:

$$\frac{T_0 - t_m}{T_0 - t_0} = \frac{4}{\pi} \sum_{n=0}^{\infty} \frac{1}{(2n+1)} e^{-(2n+1)^2\beta} \sin\frac{(2n+1)\pi}{2} \qquad (1a)$$

where $\beta = \pi^2\alpha\theta/L^2$ and t_m is the midplane temperature. The method of solution can be found in many texts on the subject of conduction. An equation such as Eq 1a converges rapidly with increasing time, and after a suitable period, only the first term is significant. The equation then reduces to

$$\frac{T_0 - t_m}{T_0 - t_0} = \frac{4}{\pi} e^{-\pi^2\alpha\theta/L^2} \qquad (3)$$

Taking the logarithm to the base 10 of Eq 3 yields

$$\log\left[\frac{T_0 - t_m}{T_0 - t_0}\right] = -\frac{\pi^2\alpha\theta}{2.303L^2} + \log\frac{4}{\pi} \qquad (4)$$

From inspection of Eq 4, it is apparent that a graph of $\log\ [(T_0 - t_m)/(T_0 - t_0)]$ against θ, the independent variable, will give a straight line whose slope m_α is given by

$$m_\alpha = -\frac{\pi^2\alpha}{(2.303)L^2} \qquad (5)$$

and whose intercept at $\theta = 0$ is $\log 4/\pi$.

By rearrangement of Eq 5 it may be seen that the diffusivity is a function of the thickness of the sample and the slope.

$$\alpha = (0.233)(L^2)m_\alpha \qquad (6)$$

The period of time elapsing before the second and subsequent terms of the infinite series may be neglected will depend on the ratio α/L^2. This period increases as the square of L and decreases with increasing values of α. From a practical standpoint, however, it is merely necessary to plot the data as indicated until the points fall on a well-defined straight line. Practically, difficulties in determining the exact time of starting may make the intercept differ from the calculated $4/\pi$, but this is of no consequence.

Thermal Conductivity:

Prior to this present work, there was no unsteady-state procedure available for measurement of thermal conductivities of poor conductors such as plastics. Consideration of the problem led to the conclusion that by introducing a metallic block of known heat capacity in between two layers of plastic and applying heat to the outside surfaces of this "sandwich," data could be obtained from which the thermal conductivity could be calculated. The principle of the method has been made the subject of a separate paper (**1**). The initial conditions are essentially the same as those for the diffusivity measurement, and the assembly is shown diagrammatically in Fig. 2.

In the conductivity procedure, the data are plotted in the same manner as for diffusivity and a measured slope m_k obtained. The value of the thermal conductivity may be calculated from this slope by the equation

$$k = -\frac{2.303L'\rho'c'}{Z} L m_k \qquad (7)$$

The primed values refer to properties of the copper block. The factor Z may be determined from the intercept of the straight line through the data. Because of the inaccuracy in determining the intercept, alternative procedures are recommended by which the value of Z is determined from the measured slope m_k and a knowledge of either the thermal diffusivity or the heat capacity of the plastic sample.

The value of Z from measurements of α and m_k is

$$Z = \frac{\sqrt{\dfrac{2.303L^2m_k}{\alpha}}}{\tan\sqrt{\dfrac{2.303L^2m_k}{\alpha}}} \qquad (8)$$

From values of the heat capacity, c,

$$Z = \frac{\lambda}{\tan\lambda} \qquad (9)$$

where λ is the first positive root of the transcendental equation

$$\lambda \tan\lambda = \left[\frac{L\rho}{L'\rho'c'}\right]c \qquad (10)$$

Solutions of Eqs 8, 9, and 10 are given in convenient graphical form in the paper (**1**) referred to previously.

Heat Capacity:

The heat capacity per unit weight, or what is frequently called specific heat, c, may be calculated from the diffusivity and the conductivity if the density, ρ, is known.

Since by definition

$$\alpha = \frac{k}{\rho c} \qquad (2)$$

$$c = \frac{k}{\rho\alpha} \qquad (11)$$

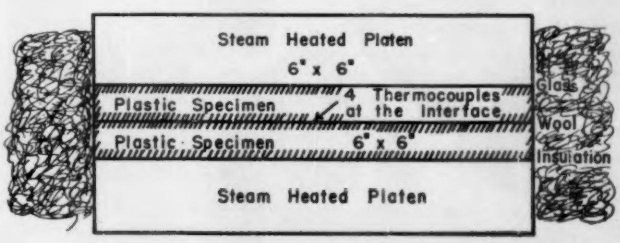


Fig. 1.—Thermal Diffusivity Assembly.

[3] See nomenclature appended to this paper.

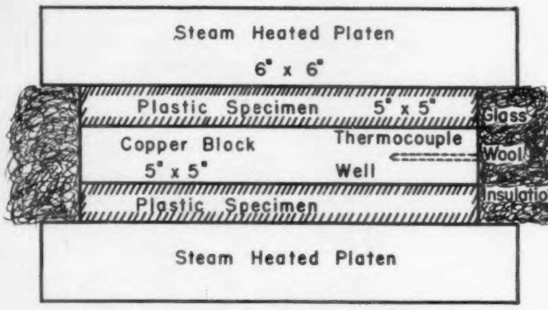


Fig. 2.—Thermal Conductivity Assembly.

By this means quick and accurate values of the heat capacity may be determined from unsteady-state measurements of k and α.

An alternative, but much less accurate, procedure involves use of the intercept value obtained in the thermal conductivity measurement. This is essentially a comparison method since it involves directly the ratio of the heat capacity of the sample to the heat capacity of the metal block used in the test. This is also true of the method using Eq 11 because the value of the heat capacity of the metal does enter into the calculation of k by Eq 7.

An entirely independent measurement of heat capacity can be made by calorimeter methods provided the calorimeter is calibrated in a manner which does not depend on the use of a material of known heat capacity. In the method to be described in the latter part of this paper, calibration was made by use of a piece of the same copper used in the conductivity measurements, so it is still a comparison method although its values are made independently of k and α.

Experimental Apparatus and Procedure

Diffusivity:

In measuring diffusivities, two pieces of plastic each 6 by 6 in. square and of equal thickness were fastened together with four No. 30 B & S gage iron-constantan thermocouples placed between them. One thermocouple junction was located at the center and one each at distances of $\frac{1}{2}$, $\frac{3}{4}$, and 1 in. from the center. This provided the equivalent of a sample 2 in. square with a 2-in. wide guard ring surrounding it with thermocouples located at the midplane.

This composite specimen was then placed between the steam-heated platens of a 6 by 6-in. Carver laboratory press. The press was closed quickly to total pressure of approximately 5000 lb. Steam pressure in the platens was continuously adjusted to maintain constant platen temperature (usually about 225 F.) as measured by thermocouples placed in wells drilled in the side of the platen. Preliminary tests had indicated that platen temperatures as measured this way were about 1.2 F. higher than platen-plastic interface temperatures measured by thermocouples. Since the thermocouples interfered with good metal-plastic contact, it was felt that the error in using platen temperatures was less than that associated with poor thermal contact. Thermal contact at the midplane is relatively unimportant since there is no heat flow across this surface. Consequently the use of thermocouples here introduced no significant error.

Prior to running a diffusivity measurement all samples were conditioned according to ASTM Method D 618 – 49 T, Procedure B,[4] by heating in a constant temperature oven at 50 C. for 48 hr and cooling in a desiccator over calcium chloride. The temperature of the specimen was taken before placing it in the press to check for complete cooling. During the test, temperatures were taken at intervals of 1 or 2 min, the latter with thick specimens. Maximum platen temperatures were held to 225 F. to avoid blistering or other degradation of the surface.

Thermal Conductivity:

The general procedure for measuring the thermal conductivity parallels that for diffusivity. Two similar specimens, 5 by 5 in. square, were placed one on each side of a 5 by 5 by $\frac{3}{4}$-in. block of high-purity, oxygen-free copper. Both faces of the block had been carefully machined to assure good contact and the block had been provided with a $\frac{1}{16}$-in. diameter hole in one edge in which a thermocouple was inserted. This three-layer sandwich was placed between the heated platens of the Carver press and the total pressure rapidly brought up to 5000 lb. Glass wool insulation was placed around the edges to reduce heat losses. It was recognized that a guard ring would have been superior, and work is now under way on building an apparatus to include this and other refinements.

All plastic samples were conditioned as previously described. The thickness of samples was measured before the test and no consideration taken of the possible compressing effect of the 200-psi pressure, as rough measurements indicated this to be negligible with the hard type of laminates used. For softer materials, slight variation in procedure would have to be made.

[4] 1949 Book of ASTM Standards, Part 6, p. 765.

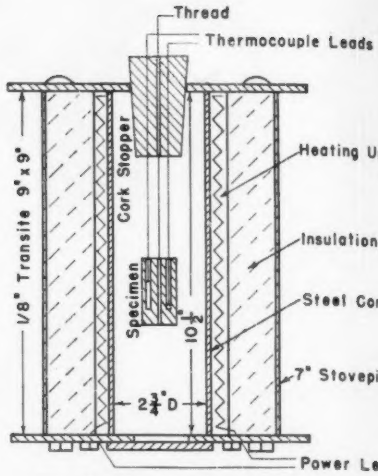


Fig. 3.—Electrically Heated Furnace.

Heat Capacity:

For the direct measurement of heat capacity, a dry type calorimeter was used based on a modification of the apparatus described by Hill and Bell (3) and by Wilkes and Wood (6). In operation a small sample was brought to temperature in an electrically heated ceramic tube (Fig. 3) placed directly over the calorimeter. When an appropriate uniform temperature had been achieved in the sample, it was dropped into the adiabatic calorimeter.

The calorimeter proper consisted of a thick-walled brass cylindrical cup provided with a lid. A sketch showing a section through the cup together with principal dimensions is given in Fig. 4. The calorimeter cup was mounted on cork supports inside a polished aluminum jacket immersed in a 12- by 12-in. cylindrical Pyrex jar filled with water. The entire assembly is shown in the sketch in Fig. 5 and the photograph in Fig. 6. The temperature of the water bath was controlled by electric heating so that it matched that of the calorimeter

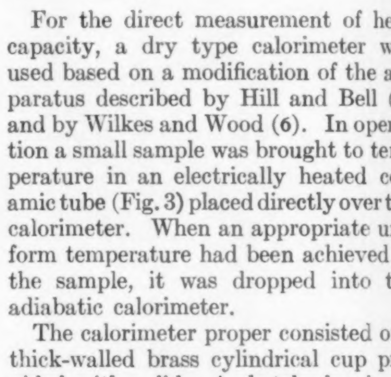
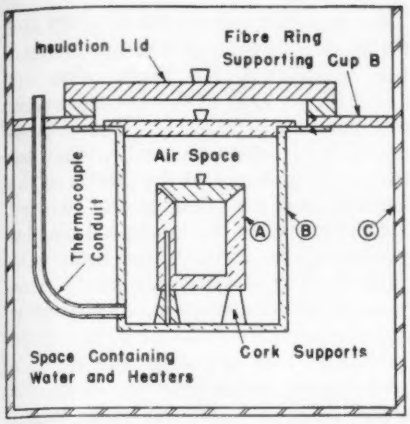


Fig. 4.—Brass Calorimeter Cup.



A- Brass Calorimeter
B - Aluminum Adiabatic Jacket
C - Pyrex Glass Jar

Fig. 5.—Adiabatic Calorimeter.

cup, thus providing adiabatic conditions.

In operation, the temperature difference between bath and brass calorimeter cup was measured by a copper-constantan differential thermocouple (No. 30 gage, B & S) attached to a portable precision potentiometer. Deflection from zero of the galvanometer was kept at a minimum by manual control of the voltage to the water bath heaters. The sensitivity was such that maximum deviations could be held to ±0.1 F.

The temperature of the brass calorimeter cup was measured using a copper-constantan thermocouple in the wall (as shown in Fig. 4) with the reference junction immersed in an ice-water bath in a thermos flask. Accuracy of ±0.025 F. was estimated for this reading.

In making an actual run, a sample consisting of four layers of $\frac{1}{2}$-in. plastic material, 1 in. square, was suspended in the center of the heating furnace. The four layers formed a block 1 by 1 by 2 in. high. A $\frac{1}{8}$-in. diameter hole drilled through the center of each layer permitted them to be tied together. Two $\frac{11}{64}$-in. diameter holes provided positions for thermocouples. Carefully weighed and conditioned specimens were suspended in the heater at 220 F. for 4 to 6 hr. Temperature variation of the heater over the sample length was of the order of 0.4 F. The temperatures of the uniformly heated sample and of the calorimeter were carefully taken at the end of the sample preheating period and the sample dropped quickly into the brass cup of the calorimeter by cutting the thread. Temperature of the water bath was continuously controlled to maintain adiabatic conditions until the calorimeter cup had reached uniform temperature. This usually required $1\frac{1}{2}$ to 2 hr.

Measurement of the calorimeter constant was made by using a high-purity copper block of known specific heat (0.0933) in place of the plastic sample. As a result of five determinations, the average value was taken as 159.3 cal per deg Cent. (0.362 Btu per deg Fahr.).

Results

The tabulated results of direct measurements of the diffusivity, conductivity, and the heat capacity by calorimeter are given in Table II. Each of the listed values of thermal diffusivity is the average of measurements on three specimens of the same material. The maximum deviation of any single measurement from the average was slightly greater than 1 per cent, and the majority had absolute variations of 0.00004 sq ft per hr or less from the values listed in the table.

Thermal conductivity results listed are based on calculations made using the average of the measured thermal diffusivities to calculate the factor Z by Eq 8. Three specimens of each material were run and values reported are averages. Maximum deviations from the average were slightly above 1 per cent, but the majority were appreciably less than this. Typical data on a diffusivity test (curve A) and for a thermal conductivity test (curve B) are given in Fig. 7.

Heat capacity values reported are the average of three determinations on different specimens of the $\frac{1}{2}$-in. material. Tests were not run on the $\frac{1}{8}$-in. thick materials. With the exception of specimens of Poly D, individual variations from the average were all less than 2 per cent and averaged about 1 per cent. Values for Poly were +2.8 per cent, +1.2 per cent, and −4.3 per cent from the average.

Density values listed for each material are averages based on the measurements of weights and dimensions of specimens used in the thermal conductivity tests.

Discussion of Results

As was pointed out previously, it is possible to calculate the heat capacity from measurements of the diffusivity and conductivity. Conversely, it is possible to use the heat capacity measurements in determining the value of Z for the conductivity measurement and combine these two to calculate the diffusivity. Finally the diffusivity and heat capacity can be directly combined to calculate the thermal conductivity. This means that the value of each property may be calculated by three methods, each of which can give different results. Table III shows a comparison of each of the properties calculated by an alternate procedure. In this table are listed values of thermal diffusivity calculated from direct measurements of heat capacity and m_k, the slope of the time-tempera-

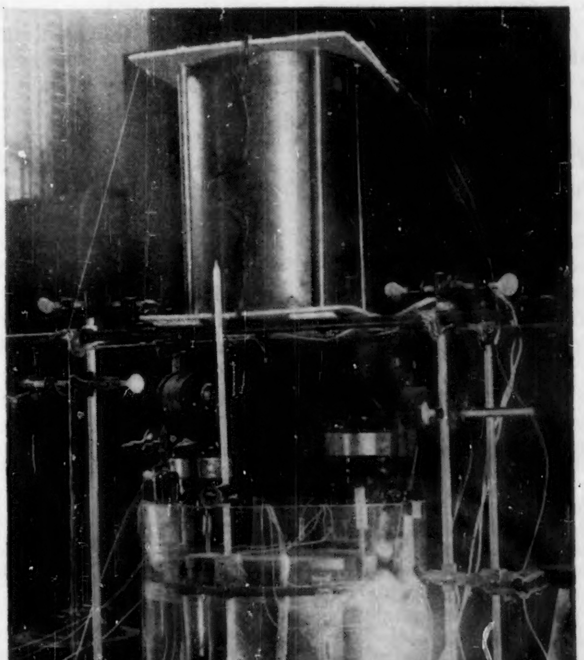


Fig. 6.—Adiabatic Calorimeter and Specimen Heater.

TABLE II.—RESULTS OF THERMAL PROPERTY MEASUREMENTS.

Type	Manufacturer	Density, ρ, lb per cu ft	Thermal Diffusivity, α, sq ft per hr	Thermal Conductivity, k, Btu per hr sq ft deg Fahr.	Heat Capacity, c, Btu per lb deg Fahr.
½-in. Sheet (Nominal)					
PBE	A	83.6	0.00483	0.166	0.409
PBE	B	83.1	0.00488	0.155	0.382
FBG	A	82.9	0.00637	0.201	0.378
FBG	B	82.1	0.00648	0.185	0.348
GBE	B	92.8	0.00613	0.180	0.315
GMG	A	117.5	0.01033	0.281	0.231
GMG	C	118.9	0.00958	0.293	0.257
Poly	D	112.2	0.00696	0.196	0.251
LPP	D	115.9	0.00917	0.247	0.232
GSG	E	101.6	0.00633	0.161	0.249
GSG	F	106.2	0.00617	0.170	0.259
MCTFE	..	132.5	0.00271	0.090	0.251
⅛-in. Sheet (Nominal)					
PBE	A	86.9	0.00508	0.167	0.379
PBE	B	82.5	0.00479	0.150	0.383
FBG	A	81.8	0.00642	0.186	0.355
FBG	B	81.5	0.00629	0.188	0.368
GBE	B	91.1	0.00513	0.162	0.346
GMG	B	118.2	0.00950	0.286	0.256
GMG	C	118.5	0.00900	0.277	0.259
Poly	D	113.1	0.00679	0.201	0.262
LPP	D	124.8	0.00808	0.258	0.272
GSG	E	100.4	0.00604	0.157	0.257
GSG	F	106.4	0.00592	0.169	0.268

ture data taken using the copper block. Thermal conductivity values are computed in two ways. In method A, k has been calculated from direct measurements of c and α; in method B from direct measurements of c (using Eq 6 of reference **1**) and m_k. In the last column are shown values of heat capacity, c, computed from α, ρ, and k of Table I.

Examination of Tables II and III reveals excellent agreement among the calculated results and indicates clearly that all three properties may be determined with satisfactory precision from unsteady-state methods. This means that all of the thermal properties may be determined with a single apparatus by two sets of measurements, each requiring less than $\frac{1}{2}$ hr for a sample 1 in. thick or less. The authors believe that the ultimate precision of these measurements can be made as high or higher than those obtainable by other accepted methods.

As has been pointed out in a previous paper (**1**), it is entirely possible to determine all *three* thermal properties from a single time-temperature plot using the conductivity method described above. This involves in addition to the slope m_k (see Fig. 7, curve A) an accurate value of the intercept at time $\theta = 0$. Unfortunately, precision of a high order is required to give accurate values of these properties and so is not recommended at the present time except for rough estimates. Work is continuing on this problem in the hope that further refinements in technique will result in a single procedure for determining all three properties with ease and precision. At present then, use of the two unsteady-state procedures for diffusivity and for conductivity is recommended for plastic materials.

The National Bureau of Standards made measurements of thermal conductivity on one sample each of a paper-base phenolic, Navy type PBE, and of a canvas-base phenolic, Navy type FBG, using the guarded hot plate method. They reported values of k of 0.139 and 0.165, respectively, at a mean temperature of about 57 F. These values are about 86 per cent of the average values of k reported in Table II. This is possibly due to better thermal contact between the platens and the plastic in the method used here than in the guarded hot plate. All of the laminated plastics used had hard surfaces, and those with glass base were extremely hard. Surfaces of these materials may vary one or two-thousandths of an inch even in good specimens. As ordinarily run there is no contact pressure between platen and sample other than that due to the weight of the top plate. With samples such as these laminates, contact must be poor under such conditions. At the 200 psi pressure used in the tests reported here some improvement is to be expected.

Another explanation of the higher conductivity values might be that the samples were slightly compressed. While this may be a contributing factor it seems probable that it is of order of magnitude less than the discrepancies observed. With softer materials, special precautions have to be taken to prevent compression. With these, however, thermal contact is no problem and hence pressure is not necessary.

The lower average test temperature used by the Bureau may also explain the difference in values. In the present case, specimens were heated from room temperature, about 75 F. to within 20 F. of the hot platen (200 F. approximately). As pointed out below, however, there was no evidence of a significant effect of temperature on conductivity for the laminates tested.

It is difficult to draw any valid general conclusions regarding the relationship of thermal properties to plastic composition. Comparison of plastic description given in Table I with the summarized results of Table II does show increased conductivities and decreased heat capacity when glass-base is substituted for a cellulosic material. This is illustrated by comparing PBE with LPP. The nature of the resin, however, does have appreciable effect on the properties too. This is brought out by the data on Poly D which show it to have low conductivity despite a high glass content. This result may indicate poor wetting or contact of the glass fiber by polyester resin, or it may be due directly to differences in the thermal properties of the resin. Measurements on the pure resin should serve to clarify this point.

The important fact is that the range in the values of the thermal properties of plastic laminates is shown to be large. This means that these variations should be taken into account in predicting the

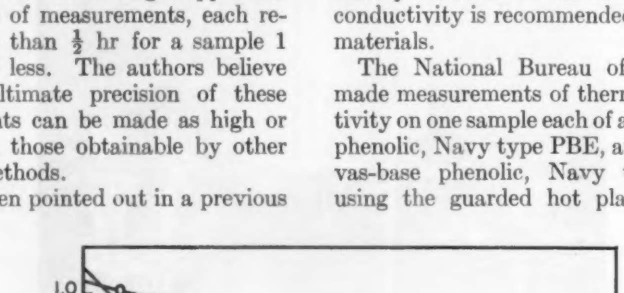


Fig. 7.—Time-Temperature Data for a Typical Diffusivity Measurement on ½-in. PBE.

TABLE III.—THERMAL PROPERTIES CALCULATED BY ALTERNATE METHODS FOR $\frac{1}{8}$-IN. MATERIALS (NOMINAL).

Type	Manufacturer	Thermal Diffusivity, α	Thermal Conductivity, k		Heat Capacity, c
			Method A	Method B	
PBE	A	0.00524	0.165	0.179	0.411
PBE	B	0.00529	0.155	0.168	0.382
FBG	A	0.00690	0.199	0.216	0.380
FBG	B	0.00704	0.185	0.201	0.348
GBE	B	0.00667	0.179	0.195	0.316
GMG	A	0.0112	0.280	0.304	0.231
GMG	C	0.0104	0.293	0.318	0.251
Poly	D	0.00752	0.196	0.212	0.251
LPP	D	0.00993	0.247	0.267	0.232
GSG	E	0.00692	0.160	0.175	0.250
GSG	F	0.00672	0.170	0.185	0.259
MCTFE	..	0.00294	0.090	0.098	0.251

extent of degradation of thick pieces upon exposure to heat. Changes in the thermal properties as a result of this exposure seriously complicate the predictions, but this may be overcome by taking similar data on partially decomposed materials. Selection of laminates for use below the decomposition temperature may also be dependent upon the properties, particularly where transient heating might occur. The differences in thermal behavior of plastic laminates of various compositions are sufficient to give preference to one material over another.

Several problems introduced with these unsteady-state procedures remain to be solved. The first of these is the question as to the temperature to which the measured value should be assigned. In both the diffusivity and the conductivity procedure, the temperature gradient and the temperature at each point within the specimen are continuously changing. It would appear that if k and α are dependent on temperature that the measured values of these properties should be subject to continuous change also. Therefore instead of a straight line on plots illustrated by Fig. 7 a curve would be anticipated. The slope of the tangent to this curve at any given time would then be proportional to the value of the conductivity or diffusivity of the sample at the appropriate average of the temperatures existing in the sample at this time. The fact that no curvature was noted even over a fairly large temperature range indicates that these thermal properties for plastic laminates are insensitive to temperature.

It is planned to make measurements on other materials whose properties are known to change with temperature. These experiments should help to confirm or disprove the anticipated curvature. An attempt is being made also to reanalyze the problem mathematically to take care of a linear change in properties with temperature.

The second problem concerns the application of these methods to nonhomogeneous materials. The laminates themselves are not homogeneous but it was felt that these could be neglected since the heterogeneities were of order of magnitude less than the thickness of the sample. Furthermore they are periodic in nature and should tend to cancel out. The consistency of the data appears to bear this out. Measurements made using several layers of plastic as a single sample gave results within experimental error of those for a single layer. These results and the general consistency of all the data justify the consideration of the plastic laminate as homogeneous for the purpose of these tests.

More complex laminates present a different picture. Data resulting from measurements on products formed of relatively thick layers of materials of different thermal properties would need careful interpretation. Where interfacial resistances between such layers may be neglected, analysis of the data can be done by graphical method. Both of these problems certainly require more study before final conclusions can be reached.

Conclusions

1. The thermal diffusivity, conductivity, and heat capacity of laminated plastics vary significantly with both the type of filler and the type of resin binder.

2. All three thermal properties (k, α, c) may be determined rapidly and accurately by unsteady-state methods if the materials may be considered as homogeneous.

Acknowledgment:

The research which served as a basis for this paper was supported in part by the Bureau of Ships, U. S. Navy Department. The authors wish to express their appreciation to the Bureau of Ships for permission to publish this paper. Thanks are also due to L. E. Sieffert for his encouragement and suggestions and to Edwin Overing for his assistance with the calculations.

Nomenclature

c = heat capacity of sample, Btu per lb deg Fahr.
c' = heat capacity of copper block, Btu per lb deg Fahr.
e = base of natural logarithms, 2.71828.
k = thermal conductivity, Btu per hr sq ft deg Fahr.
L = thickness of sample, ft.
L' = thickness of copper block, ft.
m_α = slope of plot of $\frac{T_0 - t}{T_0 - t_0}$ *versus* θ on semilogarithmic paper, reciprocal hr.
m_k = slope of plot of $\frac{T_0 - t'}{T_0 - t_0}$ *versus* θ on semilogarithmic paper, reciprocal hr.
t = temperature at any point in sample at any time, deg Fahr.
t_0 = initial uniform temperature of sample and copper block, deg Fahr.
t_m = temperature at midplane in sample, deg Fahr.
T_0 = constant elevated temperature of face, where $x = 0$, for times greater than zero, deg Fahr.
x = distance normal to surface of sample measured from heated surface.
Z = $\frac{\lambda^2}{R}$, a dimensionless factor.
α = thermal diffusivity, $k/\rho c$, sq ft per hr.
β = $\frac{\pi^2 \alpha \theta}{L^2}$.
λ = $\sqrt{ZR}$, a dimensionless factor, root of $\lambda \tan \lambda = R$.
ρ = density of sample, lb per cu ft.
ρ' = density of copper, lb per cu ft.
θ = time, hr.

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Electro Analysis of Copper*

By S. Skowronski[1]

Economic Importance

In a normal year the combined copper refineries of the United States and Canada will refine some 1¼ million tons of crude copper, shipped to the refineries in the shape of either blister pigs or anodes. The value of the copper is around 550 million dollars, and all settlements between smelter and refinery, usually on the basis of 50-ton lots, are made on the electrolytic copper analysis, and 0.1 per cent error in this analysis means a difference of 2,500,000 lb of copper with a value of $550,000.

After the copper has been refined, the cathodes and the refined shapes have to conform with ASTM Specifications B 115 and B 5[2] having a minimum copper content of 99.90 per cent. Therefore all furnace productions, usually of 300 to 400 tons each, have to be analyzed for copper content. A refinery with its incoming and outgoing products, and plant control analyses, may make as many as 100 to 200 electrolytic copper determinations a day, using overnight electrolysis (18 hr) without agitation.

When the copper reaches the fabricating plant it is checked for copper content, and the wide variety of alloys made, as well as the small furnace charges involved, necessitate many more electrolytic copper determinations, so that a large brass mill may make from 600 to 800 determinations a day, one mill reporting 300,000 electrolytic copper analyses a year during the recent World War. In the Waterbury district alone, the number of electrolytic copper determinations in a normal year will number well over a million, most of which are made with rapid plating (air circulation) using gauze electrodes and with the simultaneous determination of lead.

The reason for the universal use of the electrolytic copper determinations may be summed up in two words—simplicity and accuracy. For example, in the battery assay, ASTM Specification E 53,[3] for refined copper, there is a minimum of manipulation. The sample is weighed, dissolved without boiling, and put on the plating rack, and the sole manipulative error is limited to three weighings. The large 5-g sample taken (most refineries use 10 g) minimizes the errors due to weighing as well as to any nonuniformity of sample, so that an accuracy within 0.01 per cent is expected and normally obtained.

Historical

Although the fact that iron would displace copper from a copper solution had been known for centuries, it was not until Volta late in the 18th century invented the voltaic cell, and thus gave the world "Chemical Electricity," that the deposition of copper by means of an electrical current could be made. Cruickshank of England in 1801 published his researches on the deposition of copper by means of an electric current, and actually recommended the electrolytic deposition of copper as a qualitative separation of copper from other elements.

However, it was not until 64 years later than Prof. O. Wolcott Gibbs of Harvard University published his work on quantitative electrolytic separations. In considering the long lapse of time between Cruickshank's and Professor Gibbs' publications, it must be remembered that during this period the copper smelting industry was controlled by the Welsh, and Swansea in Wales was the copper-smelting center of the world. The Welsh had worked out a fire assay method for the determination of copper in high-grade ores, concentrates, and mattes which, while giving consistent results, was to their commercial advantage. In the 80's and 90's when considerable tonnages of copper concentrates and mattes were shipped from Arizona and Montana to Swansea, it was the custom to deduct 1.3 per cent from the electrolytic analysis in order to approximate the fire assay results.

Professor Gibbs' work came just as the copper industry of the United States was starting and Professor Cairns in his book on analytical chemistry published in 1896 writes, "The electrolytic determination of copper is so generally used in this country that it has been called the 'United States Method.' "

In 1867 the Mansfeld copper mines in Germany offered a prize of 45 English pounds for a suitable method for the determination of copper in their ores. The Mansfeld copper ore is quite complex in that it is a shale deposit containing considerable bituminous matter. At that time it was considered too low grade (6 to 9 per cent copper) for the fire assay, so they used a hydrogen sulfide separation method which was not satisfactory. There were sixteen applicants for the prize which was won by a Dr. Steinbeck for developing the cyanide method of titrating copper, similar to the method which is in use today.

Among the other methods submitted was an electrolytic deposition from a nitrate electrolyte by a Mr. M. C. Luckow, Chief Chemist of one of the German railroads. This method, due to its originality, received special mention and a consolation prize. It is remarkable how Luckow anticipated much of our present knowledge of the electrodeposition of copper.

The Luckow Method consisted of four major operations:

1. Roasting the sample (2 g) so as to eliminate the bituminous and organic matter.
2. Solution of the copper in the roasted product with 2 to 3 ml of 1.2 standard grade nitric acid and 10 to 15 drops of concentrated sulfuric acid.

   Evaporation on a sand bath for 1 hr to drive off all the sulfuric acid. The residue boiled with dilute nitric acid and the resulting solution electrolyzed.
3. Electrolysis was carried on for 8 hr with a weak current (no ammeter was available in those days). Solution tested by raising the level of the cathode stem. Platinum foil cylinders, 2½ in. in length and 1¼ in. in diameter were used as cathodes and platinum spirals as anodes.
4. Weighing the cathode deposit, first immersing the cathode in water, then in alcohol, and drying before weighing.

The Mansfeld ores carry some man-

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* Presented at a meeting of Division G on General Analytical Methods of ASTM Committee E-3 on Chemical Analysis of Metals held in Cambridge, Mass., September 15, 1950.

[1] International Smelting and Refining Co., Raritan Copper Works, Perth Amboy, N. J.

[2] Standard Specifications for Electrolytic Cathode Copper (B 115–43) and for Electrolytic Copper Wire Brass, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 5–43), 1949 Book of ASTM Standards, Part 2, pp. 338 and 319, respectively.

[3] Standard Method for Chemical Analysis of Copper (Electrolytic Determination of Copper) (E 53–48), 1950 Book of ASTM Methods of Chemical Analysis of Metals, p. 306.

ganese, enough to give a permanganic acid reaction during the electrolysis, and Luckow added a few drops of concentrated tartaric acid solution in order to reduce the permanganic acid.

While Luckow may have thought he had a straight nitric acid solution, he actually did not. It was a mixed electrolyte of nitric and sulfuric acids. Granting that he could have driven off the free sulfuric by heating on a sand bath for 1 hr, he certainly could not have decomposed the sulfate compounds at that temperature since copper sulfate does not start to desulfatize under 1200 F.

In 1881 in the United States, a Mr. Mackintosh of Hoboken, N. J., published in the *American Chemical Journal* his experience with the Luckow method for the analysis of copper alloys. Mackintosh dissolved copper alloys in nitric acid and found that the electrolytic deposition was extremely slow and never complete. In order to get around this, he added citric acid to his electrolyte which solved the problem of deposition, but gave him results anywhere from 0.75 to 1.50 per cent too high, due to carbon contamination of the copper deposit.

Comparative results were as follows:

Using a 1-g Sample of	Copper Deposited, per cent		
	Sulfuric Acid	Nitric and Citric Acids	Difference
Pig copper	98.00	99.42	+1.42
	99.80	101.22	+1.42
	98.92	100.41	+1.49
	98.72	100.27	+1.55
	99.60	100.45	+0.85
Brass.........	65.83	66.93	+1.10
	65.83	66.58	+0.75

Mackintosh must have been quite a thorough chemist, for somehow he was able to strip off the copper deposit, which he found to be exceedingly brittle, and to analyze it for carbon, hydrogen, and oxygen. He found considerable carbon, some hydrogen, but no oxygen.

His final conclusions were as follows:

"The practical conclusions to be drawn from these results are that some organic matters, and in all probability all, in the presence of nitric acid in the copper solution undergoing electrolysis, cause erroneous results; that from a nitric acid solution, with no organic matter it is extremely difficult to separate all the copper; and that the old method of electrolysis from the sulfate is the best."

In the United States, the states of Michigan and Montana were our first large producers of copper, and it is natural that the chemists of these two states became pioneers to blaze the way for others to follow. We owe a great deal to George L. Heath of Michigan and to Dr. Edward Keller of Montana. The work of the two men went along quite different lines. Michigan copper being fairly pure, Heath was essentially a pure-metal man, and ASTM Method E 53–48[3] for the analysis of refined copper and casting coppers is essentially Heath's method. On the other hand, Montana copper is high in silver content, as well as in impurities such as arsenic, antimony, selenium, and tellurium. Consequently, Keller was a pioneer in the analysis of impure and high-silver-bearing copper. Keller was best known for his work in the sampling of blister copper and his monograph on the subject, published by the Bureau of Mines, remains a classic to this day.

Both men were active until about 1920 and both were generous in their contributions to the literature of their time, laying a good foundation for the modern methods of the analysis of copper-bearing materials.

Commercial Electrolytes

Sulfates:

While copper sulfate was the first commercial electrolyte suggested for the electrolytic determination of copper, its use is not satisfactory and cannot be recommended. Toward the end of the deposition, due to the formation of cuprous sulfate, cuprous oxide (Cu_2O) or finely divided metallic copper is deposited upon the cathode in a loose condition and may readily be removed.

In the presence of impurities such as arsenic, antimony, or tellurium, the deposit is quite hopeless, being spongy (and usually nonadherent) due to the formation of arsenides, antimonides, and tellurides of copper.

It is remarkable, however, how the addition of a small amount of nitric acid (0.5 ml) to a sulfate electrolyte will give a good deposit in the absence of the above impurities.

Nitrates:

Mackintosh's experience with the nitrate electrolyte has already been given, and he was correct in his conclusions. Yet, this electrolyte is widely used by the brass companies in the simultaneous determination of copper and lead.

Years ago it was found that tap water would give better plating and better results than the use of distilled water in the makeup of the electrolyte. Investigation showed that chlorine in the tap water was the beneficial factor, and it became the custom to add 1 to 2 drops of 0.1 *N* HCl to the nitrate electrolyte made up with distilled water. In 1939 the Bureau of Standards made a thorough investigation of the subject and confirmed the value of the addition of the 1 to 2 drops of 0.1 *N* HCl, showing some remarkable copper recoveries based upon known copper additions.

A straight nitrate electrolyte, as shown by Mackintosh, gives a very slow deposition of copper and a poor deposit.

Three cells run in series by the author, plating out 1 g of copper, gave the following results:

	Current Efficiency, per cent
1. Mixed H_2SO_4 and HNO_3—91 per cent of the copper had deposited at...........................	95
2. HNO_3—12 per cent of the copper had deposited at..............	13
3. HNO_3 and two drops 0.1 *N* HCl—95 per cent of the copper had deposited at.....................	99

Solutions were electrolyzed at 0.27 amp for 3 hr and current stopped before electrolysis had been completed.

In the nitric acid bath with no chloride added, it is a noticeable fact that the cathode is covered with fine bubbles of hydrogen gas, and the copper can only plate between the bubbles at a high current density, resulting in an off-color deposit. The addition of a trace of HCl worked like magic, the cathode in the nitrate electrolyte with the addition of 2 drops of 0.1 *N* HCl being totally free from gas bubbles. Although nitric acid is known to be a good depolarizer for hydrogen gas, it did not so function in a nitric acid bath without chloride. This suggests the possibility that the chlorine ion acts as a catalyst in causing the nitric acid to depolarize the hydrogen gas. In all of this work the rate of deposition from the nitrate and chloride bath is slightly faster than from the mixed H_2SO_4 and HNO_3 bath, and the current efficiency percentages, 99 per cent *versus* 95 per cent, represent the rate of deposition from the two baths.

Under normal conditions where lead is not being determined, the sulfate-nitrate electrolyte is more simple to use than the nitric acid and chloride bath and is to be preferred.

On the simultaneous determination of copper and lead, some laboratories start with the nitrate bath and add sulfuric acid after the deposition of the lead, to complete the deposition of the copper.

Mixed Sulfates and Nitrates:

There is no record of who originated the mixed sulfuric-nitric acid bath. Luckow undoubtedly had it but did not realize its value.

An improvement in the dissolving of copper and copper alloy samples was made in 1905 when Hollard suggested the use of a mixture of sulfuric and nitric acids to dissolve such samples.

When nitric acid alone is used to dissolve copper, copper nitrate is formed. In using mixed sulfuric and nitric acids, however, the sulfuric acid is the active solvent, the nitric acid acting as the oxidizing agent; therefore, less nitric acid is required for solubility.

Electrodes

Sheet or Foil versus Gauze and Perforated:

Platinum electrodes have been used exclusively in the determination of copper. Usually 10 per cent iridium is specified to harden the platinum. Five per cent iridium has been tried but has not been as successful as the 10 per cent alloy. Rhodium is also used to harden the platinum.

The first form of electrode (cathode) was circular, made of sheet or foil platinum, but various other forms have been used. Luckow used a conical-shaped cathode, while Classen did practically all his work using platinum dishes as cathodes.

Anodes have usually been platinum spirals, the advantage of gaseous stirring of the electrolyte being realized from the start. Luckow's original anode had a horizontal coil at the bottom which was slightly larger than the diameter of the cathode.

Hollard had an anode that was shaped like a basket into which the cathode could be set.

In 1899 came a startling innovation when Winkler of Germany recommended a cathode cylinder made of platinum wire gauze (wire 0.12 mm thick—250 mesh per sq cm). Due to the increased circulation with gauze cathodes, much higher current densities could be used than on a sheet or foil cathode, and much larger samples (up to 10 g) could be taken for analysis without increasing the time of deposition. Gauze electrodes both for cathodes and anodes are today standard in the brass industry, where lead is simultaneously determined with the copper (Fig. 2).

The copper refineries, however, did not like the gauze cathodes as their loss in weight, due to use, was excessive. Consequently, Keller in 1909 came out with a perforated sheet cylinder which is shown in Fig. 1.

This cylinder is considerably larger than the average cylinder used. It has 146 sq cm of surface area compared with the ASTM standard of 94 sq cm. The average weight of a cylinder is 21 g. The loss in weight of cylinders is about 1 mg in four months. One refinery reports a gain in weight of 1 mg per year.

This cathode is especially suited for a 10-g sample on refined copper and a 5-g sample on impure or blister copper. It may be used for a 2- or a 1-g sample, but in these cases the smaller ASTM size is better suited; not that the size of the cylinder is important, but the volume of electrolyte is important. The Keller cylinder in a 400-ml beaker will require 270 ml of electrolyte, compared with the ASTM specified volume of 150 ml of electrolyte.

In 1903 in the *American Journal of Science*, Professor Gooch of Yale University described his rotating cathode by the use of which he was able to deposit 0.25 g of copper in 25 min.

In the same year in the *Journal* of the American Chemical Society, Exner described his rotating anode.

Dr. Frary's solenoid for circulation of electrolytes dates back to 1907.

Current Density and Time Factor

According to Faraday's law a current of 1 amp-hr will deposit 1.185 g of copper, or 0.843 amp-hr is required for the deposition of 1 g of copper.

From a still electrolyte with stationary electrodes 95 per cent of the copper may plate out at a good ampere efficiency, but the remaining 5 per cent may take hours, thus lengthening the time required for complete deposition. This has led to the universal practice in copper refineries of overnight deposition. Thus, one refinery will plate out 10 g of copper with 1 amp in 18 hr, and 5 g of copper with 0.5 amp in the same time. The ASTM Method E 53[3] specifies 0.6 amp for 16 hr for a 5-g sample of refined copper.

Fig. 1.—Platinum Cylinder and Spiral

Fig. 2.—Platinum Electrodes for Electro-Analysis

However, it is possible with a gauze cathode and agitation of some sort, such as air circulation or a rotating electrode, to deposit 5 g of copper in 4 hr with 4 amp. Even with stationary electrodes there will be no difficulty in completely depositing 2 g of copper in 4 hr with a current of 1.5 to 2.0 amp.

Effect of Interfering Elements

Metals More Noble than Copper:

Gold, mercury, platinum group metals, and silver will naturally deposit before the copper. About the only one of these metals likely to be met in copper analysis is silver. Up to 50 oz per ton (0.17 per cent) of silver, the cathode deposit of copper and silver will be smooth, and the silver value may be subtracted from the total deposit, to give an accurate copper content. With more than 50 oz per ton of silver, the deposit becomes rough, and beyond 100 oz per ton of silver (0.34 per cent) the deposit may be so rough that the accuracy of the copper determination is in doubt. Therefore, some refineries are still removing all of the silver as silver chloride prior to electrolysis.

One refinery with silver in the anodes running around 70 oz per ton is electrolyzing 1 g of copper, dissolved in nitric acid, with the very low current of 0.01 amp for 3 hr, during which time only the silver is deposited. Five milliliters of sulfuric acid and 5 ml of a saturated solution of ammonium nitrate are then added to the electrolyte and the electrolysis continued overnight with 0.2 amp, resulting in a smooth deposit of silver plus copper.

The removal of selenium and tellurium has always been troublesome. Formerly it was a refinery chemist's problem, but today with fire-refined copper permitted to contain 0.025 per cent maximum selenium plus tellurium, with commercial copper-tellurium alloys containing up to 0.60 per cent tellurium, and with copper-selenium alloys containing up to 0.60 per cent selenium, the problem is also one for the fabricator's laboratory.

The crux of this problem is complete oxidation, and if selenium and tellurium can be oxidized to the hexavalent condition and kept there during the electrolysis, neither will deposit upon the cathode.

Selenium is difficult to oxidize, and in the ordinary method of analysis from 50 to 80 per cent of the selenium present will deposit ahead of the copper on the cathode cylinder where it can plainly be seen as a dark deposit.

While tellurium is easier to oxidize than selenium, it is also easier to reduce, so that the tellurium usually deposits after the deposition of the copper and gives a characteristic black or black-streaked deposit.

We are indebted to Prof. N. H. Furman of Princeton University for the use of potassium persulfate as a strong oxidizing agent for selenium. If an ammoniacal solution of copper containing selenium is boiled with 1 g of potassium persulfate, the selenium will be effectively oxidized. The solution can then be made acid, cooled, and electrolyzed without any selenium being deposited wih the copper, either at the beginning or at the finish of the electrolysis.

While tellurium can be oxidized in the same manner, the potassium persulfate loses its oxidizing power toward the end of the electrolysis so that the tellurium becomes reduced and deposits on the cathode.

In order to have a strong oxidizing condition toward the end of the electrolysis, the chemists of the Chase Brass and Copper Co. are adding a solution of manganese nitrate, made by dissolving electrolytic manganese in nitric acid, to the electrolyte. In the analysis of tellurium-copper (0.60 per cent tellurium), a 2-g sample is dissolved in sulfuric and nitric acids, 2 ml of a 1 per cent manganese solution is added, and the solution electrolyzed at a current density of 2 to 3 amp per sq dm, using a gauze cathode and air agitation. The permanganic acid formed during the electrolysis is an effective oxidizing agent and prevents not only tellurium but also arsenic, antimony, and selenium from depositing with the copper toward the end of the electrolysis. The author considers the use of manganese nitrate in the electrolytic determination of copper in impure copper samples one of the most important improvements made in the electrolytic method in many years. Since selenium deposits before the copper at the start of the electrolysis, manganese nitrate is not effective as an oxidizing agent when selenium is present, and the potassium persulfate method must be used.

Border Line Metals:

When arsenic is present in amounts less than 0.2 per cent, little or no arsenic will deposit with the copper. If present in larger quantities, a considerable percentage of the arsenic will deposit on the cathode toward the end of the electrolysis, giving the copper deposit a light-grayish appearance. Antimony acts much like arsenic, part of it depositing along with the copper. The color of the deposit due to antimony is somewhat darker than the color due to arsenic. Antimony will increase the percentage of arsenic depositing on the cathode, and in the presence of large quantities of arsenic and antimony, some of the lead, if present, will also deposit on the cathode. The old standard procedure, if the cathode is dark due to the above elements, is to dissolve the copper from the platinum cylinder and replate, in accordance with ASTM Method E 53.

Here again the problem is one of oxidation, and if arsenic and antimony can be kept oxidized they will not deposit with the copper. In 1905 Hollard suggested the addition of iron to form ferric arsenate. The common oxidizing agent used is ammonium nitrate, 10 to 30 ml of a saturated solution being added to the electrolyte, but manganese nitrate should be a more powerful oxidizer. Using the latter, it is possible to deposit copper from a 2½ per cent copper-antimony alloy and obtain a satisfactory deposit with no antimony deposition. Consequently, the use of manganese nitrate in combination with ammonium nitrate will eliminate much of the replating hitherto necessary for satisfactory results.

So far no separation of the bismuth from copper has been obtained by electrolysis. If bismuth is present, it will completely deposit with the copper and must either be removed before electrolysis or determined in the cathode deposit.

Molybdenum in small quantities is found more frequently in copper ores than is generally supposed. In electroanalysis it acts similarly to arsenic and antimony in that part of it deposits with the copper. When not too much molybdenum is present, the addition of a small amount of a chloride will prevent its deposition entirely. One milligram of sodium chloride will effectually prevent the deposition of about 6 mg of molybdenum.

In a nitrate electrolyte, tin is precipitated as the metastannic acid and may hold up some copper. An old method of eliminating this is given in Post and Neuman's Analytical Chemistry Metal Volume (German). The copper-tin alloy is dissolved in fuming nitric acid (sp gr 1.50) after which the solution is boiled with 50 ml. of water and filtered. The resulting tin oxide will be granular, filtering readily without sliming, and will hold up little, if any, copper and lead. Moreover, the oxide of tin so precipitated is soluble in hydrochloric acid, thus giving an opportunity for the determination of arsenic and antimony if required and the final determination of the tin, either by electrolysis or titration.

Halogens:

The addition of 1 to 3 drops of 0.1 *N*

HCl to a copper nitrate electrolyte has already been discussed, and it was shown that the nitrate electrolyte will not work unless a trace of hydrochloric acid is present.

In the commonly used mixed electrolyte of sulfates and nitrates, Keller, Heath, and others have strongly asserted that chlorides must be completely absent. In view of these statements, the following experiment was made. One, two, and three drops of 0.1 *N* HCl were added to a standard refined copper determination, using mixed electrolyte. (Sample 10 g of refined copper. Electrolysis for 18 hr at 1 amp and a volume of electrolyte of 260 ml.) The effect was marked even with the addition of 1 drop and grew worse with the 2- and 3-drop additions. All deposits tended to be spongy due to needle formation of the copper crystals deposited. This was marked at the bottom of the cylinders and at the perforations, some of the latter being completely closed by needle crystal formation.

Therefore, it can be said that in a mixed acid electrolyte the addition of a chloride is neither necessary nor desirable and is not to be recommended. It should be noted, however, that the analytical results were satisfactory:

	Copper, per cent
Blank (no Cl)	99.961
+1 drop 0.1 *N* HCl	99.963
+2 drops 0.1 *N* HCl	99.960
+3 drops 0.1 *N* HCl	99.958

The National Bureau of Standards reports that on a nitrate electrolyte, bromides and iodides acted in a manner similar to that observed with the addition of chlorides but tended to give high results. On a mixed electrolyte, the addition of bromides or iodides tended to make the deposit spongy and off color.

Metals with Two States of Oxidation:

Copper is appreciably soluble in solutions containing metal salts with two states of oxidation.

Iron.—Varying amounts of iron as ferric sulfate were added to a regular electrolysis of refined copper. (Copper sample 10 g, time of deposition 18 hr at 1 amp current, and 260 ml volume of electrolyte.)

Equivalent Iron Added, g	Equivalent per cent Iron	Per cent Copper Found
Blank	..	99.968
0.01	0.10	99.967
0.025	0.25	99.970
0.050	0.50	99.970
0.10	1.00	99.790
0.25	2.50	93.683
0.50	5.00	82.790

Therefore, in ASTM Method E 53, the percentage of iron in the sample should not be over 0.50 per cent for accurate results.

However, copper will deposit completely in the presence of considerable iron, provided the nitrate concentration of the electrolyte is controlled and kept at a minumum. Copper can be determined in an iron cinder containing 1.5 per cent copper and 50 per cent iron, provided that only 0.5 to 1.0 ml of nitric acid is added to the sulfate solution prior to deposition. The same will apply to ores, concentrates, mattes, and other metallurgical products.

The author added varying amounts of nitric acid to 150 ml of a solution containing 20 g of copper sulfate (5 g copper) and 5 g of ferric sulfate (1.4 g iron). Copper was completely deposited on the addition of 0.5, 1.0, and 2.0 ml of nitric acid, but was not completely deposited with the addition of 3.0 ml of nitric acid.

Manganese.—Since the addition of manganese nitrate has been recommended to prevent the deposition of impurities, it is important to know whether manganese will have any effect upon the accuracy of the copper determination. In order to check this point, the following experimental electrolyses were made.

The addition of varying amounts of a manganese nitrate solution, made by dissolving metallic manganese in nitric acid, to the electrolyte of a refined copper electrolysis (10-g sample, current 1 amp for 18 hr, and a volume of electrolyte of 260 ml), gave the following results:

	Copper, per cent
Blank	99.968
Addition of 0.020 g. manganese	99.970
Addition of 0.050 g manganese	99.967
Addition of 0.100 g manganese	99.970

The experiment was repeated using a 5-g sample. (Current 0.5 amp for 18 hr and volume of electrolyte 150 ml.) (ASTM Method E 53.)

	Copper, per cent
Blank	99.932
Addition of 0.020 g manganese	99.932
Addition of 0.050 g manganese	99.928
Addition of 0.100 g manganese	99.934

The electrolytic deposit of copper was very good, and the addition of the manganese nitrate up to 0.10 g had no effect upon the accuracy of the determination.

Chromium—In order to check on this element, chromium as chromic sulfate was added to a 10-g determination of copper with the following results:

	Copper, per cent
Blank	99.968
Addition of 0.05 g chromium	99.968
Addition of 0.10 g chromium	99.969
Addition of 0.25 g chromium	99.971

Chromium is seldom encountered in a copper determination, but if it is present in the electrolyte as chromic sulfate, it will not interfere with the accuracy of the determination.

Nitrous Oxides:

Copper will not deposit and will dissolve from the cathode in the presence of nitrous oxides.

After dissolving either in nitric acid or in mixed acids, the solution should be heated carefully in order to drive off the nitrous oxides. In order to counteract the effect of nitrous oxides that might be formed during and at the finish of the copper deposition, some laboratories are adding either sulfamic acid or urea to the electrolyte.

While there is no objection to the addition of sulfamic acid, the addition of urea to the electrolyte at any stage of the electrolysis is not to be recommended, because of the possibility of carbon contamination of the copper deposit.

Organic Matter—Carbon Compounds:

Organic matter in a copper electrolyte has a far greater effect on the accuracy of the copper determination than most chemists realize. Organic matter in a copper sample, particularly in scrap material which has not been previously burned, will generally cause a black spongy deposit. Such a sample, after dissolving in nitric acid and adding sulfuric acid, should be evaporated to fumes and heated until the organic matter is completely decomposed and destroyed.

Prof. George Guess in 1905 recommended the use of a nitrated oil, obtained by heating and boiling No. 4 hard oil (petroleum jelly) with concentrated nitric acid. The mixture was allowed to cool, upon which the undecomposed oil would rise to the surface and leave a nitrated oil. The recommendation was to use a few drops of the nitrated oil in a copper determination. This gave a remarkably dense and smooth copper deposit, but with results anywhere from 0.5 to 1.0 per cent too high.

The experience of Mackintosh in adding citric acid to a copper electrolyte and obtaining carbon contamination of the copper deposit has already been given. Since some laboratories are adding urea to the electrolyte for copper determination, an experiment was conducted adding varying weights of urea to a determination of refined copper (10-g sample, 1 amp current for 18 hr, volume of electrolyte 260 ml).

	Copper, per cent
Blank	99.966
Addition of 0.5 g urea	100.013
Addition of 1.0 g urea	101.743
Addition of 2.0 g urea	101.612

The copper deposit was smooth, had the correct color, and showed no indication whatsoever of carbon contamination.

The author agrees with the conclusions of Mackintosh that all organic matter of any kind and type should be kept out of a copper electrolyte used for the determination of copper.

Some years ago the author found that if 20 to 30 ml. of a saturated solution of ammonium nitrate containing 20 g per liter of manganous sulfate was added to an electrolyte carrying dissolved organic matter, a good deposit of copper could be obtained without the tedious operation of evaporating the solution to fumes of sulfuric acid for the destruction of the organic matter.

Effect of Temperature

The electrolytic determination of copper is usually made at room temperature without paying any particular attention to the actual temperature of the electrolyte. If the electrolyte is allowed to rise to too high a temperature, the copper will either redissolve or will not plate out. It is not an uncommon occurrence on an unusually hot night for all the copper determinations, started the day before, to show copper in solution the following morning. Obviously, the current density must be increased to counteract the increased solubility of the copper at the higher temperature.

During the electrolysis the electrolyte will heat up because of electrical energy which is dissipated into heat. Even though the electrical energy is not great, the volume of electrolyte is small. Consequently, there is an appreciable difference in temperature between the room and the electrolyte. For example, on the analysis of a 10-g sample of refined copper with 1 amp current and a volume of electrolyte of 260 ml with 18 hr deposition, the temperature of the electrolyte in the morning varied from 92 to 95 F. compared to the room temperature of 78 F.

Similarly, a 5-g sample deposited with 0.5 amp current, 260 ml volume, gave a temperature at the finish of the electrolysis of 86 F. as against a room temperature of 78 F. A 5-g sample deposited with 0.5 amp current, 150 ml volume (Method E 53), at a room temperature of 70 F. showed a temperature of 80 F. at the end of the electrolysis.

The addition of "dope" such as ammonium nitrate will increase the resistivity of the electrolyte and increase the temperature differential, which may cause redissolving of the copper deposit. For example, two 5-g samples of refined copper were analyzed following Method E 53 procedure, but to one of them an excessive amount of ammonium nitrate was added, 50 ml of a saturated solution to a total volume of 150 ml of electrolyte. In the morning the electrolysis of the normal electrolyte was finished and the deposition was complete at a temperature of 88 F. against a room temperature of 78 F. The electrolysis with the addition of the ammonium nitrate was not complete and the temperature of the electrolyte was 112 F., a differential from the room temperature of 34 F. At that temperature the copper deposit redissolved. Even smaller amounts of ammonium nitrate additions, 10, 20, and 30 ml to a volume of 260 ml, will slow up the copper deposition and the copper may show on the stem of the cathode on testing for complete deposition after 18 hr of electrolysis.

Therefore, the temperature of the electrolyte during and at the finish of an analysis is important, and if electrolysis could be carried on in an air-conditioned room at 60 F., more consistent results with greater accuracy would be obtained.

Determination of Traces of Copper (Less than 1 mg)

E. E. Free in 1907 in Volume 12 of the *Transactions*, Am. Electro-chemical Soc. published a method for the electrolytic determination of minute quantities of copper.

The electrolysis was made using 25 ml of an electrolyte composed of 2 to 4 per cent nitric acid and a few drops of sulfuric acid. The electrolysis was carried on overnight with a current of 0.01 amp at 1.8 v. The anode was a platinum crucible which held the electrolyte. The cathode was made from a small piece of platinum wire bent into a spiral with one end extending along its axis. It was supported in the bath by wrapping this free end four or five times about a hook of platinum wire. No cathode dimensions were given but its weight was about 0.3 g. A button balance (gold) was used to weight the cathode.

Following are some of Free's results, the first four obtained by electrolyzing a solution of known strength, the last two by redissolving the copper from one precipitation and reprecipitating on another electrode.

	Copper Present, mg	Copper Found, mg
No. 1	0.529	0.509
No. 2	0.494	0.498
No. 3	0.556	0.558
No. 4	0.499	0.500

	Copper Found, mg	
	First Precipitation	Second Precipitation
No. 5	0.092	0.104
No. 6	0.348	0.344

Dr. Free's conclusions were particularly interesting:

> "Uniformly good deposits are obtained from solutions containing nothing but copper salts and acids. If, however, compounds of carbon or of platinum (derived from platinum dishes during preliminary treatment) are present, the deposit will be black and loosely adherent owing to contamination with these elements and results high. Organic matter dissolved in the disintegration of a filter paper by nitric acid will in this way seriously interfere with the obtaining of a good deposit."

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Sampling of Ferrous and Non-Ferrous Alloys—A Bibliography

Prepared under the Auspices of ASTM Committee E-3, Division S, Subcommittee S-2

By Albert C. Holler,[1] Chairman

Preface

This bibliography was prepared under the auspices of ASTM Committee E-3 on Chemical Analysis of Metals through its Division S, Subcommittee S-2 on Sampling of Non-Ferrous Alloys, is intended to serve as a guide to future sampling techniques. The literature surveyed included *Chemical Abstracts* up through 1949 and the various books and journals available to the writer. It is published here in the belief that it is of interest to many ASTM members and other readers of the ASTM Bulletin.

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Effect of Fungus Growth on the Tensile Strength of Pressure-Sensitive Electrical Insulating Tapes

By Sigmund Berk[1] and Leonard Teitell[1]

SYNOPSIS

Twenty-three pressure-sensitive electrical insulating tapes were tested for fungus resistance using a mixed spore suspension of five species of fungi. The cellulose acetate, vinyl, and polyethylene tapes supported no more than slight mold growth, the glass fabric tapes supported no growth to heavy growth, while the paper and cloth tapes were very susceptible to mold attack. Results of breaking strength losses after exposure to mold are given. A yellow flat stock paper tape was treated with four fungicides and tested for fungus resistance. Good protection against mold growth was afforded by 0.84 per cent phenyl mercuric saccharinate.

In the recent World War, failure of electrical equipment due to moisture and fungi was of frequent occurrence, especially in tropical areas or after long storage under conditions of high humidity. There is some controversy whether fungus growth is of primary or secondary importance in the failure of equipment in service (**7,8**).[2] Titus (**12**) reported that fungus mycelium might cause flashover when bridging high-voltage terminals. It has also been reported by Proskauer and Smith (**9**) that microorganisms contribute to the retention of moisture on surfaces that would normally dry out more quickly, and their presence might produce paths of low electrical resistance.

Ezekiel (**6**) states that Luce and Mathes found that the injurious effect of molds is evident in the deterioration of the electrical properties of hook-up wires considerably before mold growth is evident. He also found that this effect is apparent even in those cases where visible mold growth never occurs, that is, "subvisual mold growth only is present."

Government laboratories have conducted fungus tests on electrical tapes with the purpose of determining their susceptibility to mold growth and their ability to meet specification requirements for mold resistance.

The purpose of this investigation was to determine the fungus susceptibility of pressure-sensitive electrical adhesive tapes for inclusion in a proposed specification. The extreme susceptibility to deterioration by fungi of friction tape (cotton sheeting coated and impregnated with a rubber frictioning compound) had previously been observed in this laboratory. Attempts have also been made to fungus-proof friction tape with salicylanilide, 2,2′-methylene bis (4-chlorophenol), and other fungicides. Although these chemicals offered good protection against mold attack to textiles, they offered little or no mold resistance to friction tape.

Much work has been done and reported in the literature on the fungus susceptibility of plastics, paper, textiles, and adhesives. There are also many patents on new types of materials for tape backings and formulations for adhesives. However, the literature contains only passing references (**8**) on the susceptibility to fungi of pressure-sensitive electrical insulating tapes.

Pressure-sensitive tapes are composed of two essential parts, a backing material and an adhesive. The following have been used as backing materials: paper, cotton sheeting, glass fabric, cellulose acetate cloth, vinyl resin films, cellulose acetate film, polyethylene, polystyrene, and neoprene. Delmonte (**5**) states that the term "pressure-sensitive adhesive" is applied to this type of tape because the tape can be pressed upon many types of surfaces with finger pressure and be made to adhere upon contact. He also defines a pressure-sensitive adhesive as an organic material capable of producing a substantially permanent union between two or more materials. Adhesives used for pressure-sensitive tapes are divided into the following types based on the substances from which they are prepared: synthetic resin, synthetic resin-rubber, natural and synthetic rubbers, protein, and cellulosic derivatives. The adhesive is usually applied to the backing material, except in the case of friction tape where the cloth backing is coated and also impregnated with the frictioning compound. The adhesives used in the tapes tested were: natural,

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[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

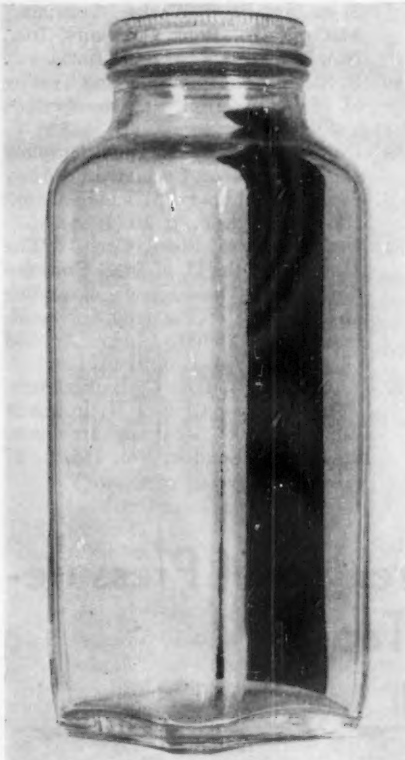


Fig. 1.—French Square Bottle (16 oz) Used as an Incubation Chamber with Sample of Insulating Tape on Solidified Nonnutrient Mineral Salts Agar.

reclaimed, or synthetic rubbers; synthetic resinous materials; or protein materials. More detailed information on the composition of the adhesive layer is not available since the art is considered confidential by the manufacturers. However, it is known from the literature (**2, 5**) that many paper tapes are backsized with a glue-glycerol solution or shellac and a number of rubber and resin adhesive coats applied.

This report is concerned with the susceptibility to fungi of 23 electrical insulating synthetic resinous adhesive tapes. The tapes, supplied by four manufacturers, consisted of the following types: glass fabric backing, synthetic fabric backing (cellulose acetate cloth), synthetic fabric and resinous backing (cellulose acetate film laminated to cellulose acetate cloth), synthetic resinous backing (cellulose acetate film, cellulose acetate butyrate film, vinyl resin film, polyethylene film, and neoprene), paper backing (flat and crepe), and cloth fabric. In addition to susceptibility to mold, the effects of the mold growth on the loss in breaking strength of the incubated tapes were determined.

A paper tape was also treated with four fungicides and its mold resistance determined.

Procedure

Forty-milliliter portions of nonnutrient mineral salts agar medium[3] (FA No. 5) were poured into 16-oz French square bottles. The bottles containing the medium were sterilized at 15 lb steam pressure for 20 min and placed on their sides to cool. Six-inch strips (varying in width from $\frac{3}{4}$ to 1 in.) of the tapes listed in Table I were placed on the solidified medium in the bottles (Fig. 1). For each type of tape, six specimens were incubated with the adhesive in contact with the agar medium (incubation method A in Table I) and six with the backing material in contact with the agar (incubation method B in Table I).

The fungi used as a source of inoculum were grown on slants of modified Czapek's agar[4] in culture tubes at 29 ±1 C. The following test organisms were used: *Chaetomium globosum*, FA No. 82 (ATCC[5] No. 6205), *Aspergillus niger*, FA No. 13 (ATCC No. 215-4247), *A. flavus*, FA No. 9 (BPI 1003a), *Trichoderma* sp., FA No. 69 (ATCC No. 9645), and *Penicillium luteum*, FA No. 50 (ATCC No. 1124.)

Since some of the tapes tested were constructed of cellulosic materials, *C globosum* (which is widely used as a laboratory test organism for determining cellulose decomposition) was used as a test organism. *A. niger* was chosen for its common occurrence in nature, and for its affinity for protein materials. *A flavus* and *P. luteum* are used for determining the fungus resistance of plastics. *Trichoderma* sp. was selected for its rapid growth rate, its cellulose destroying properties, and its ubiquitous occurrence in soil flora.

The mixed spore suspension was prepared by scraping the surface growth from the culture of the test organism with a sterile platinum needle. The spore charge was deposited in a sterile 300-ml Erlenmeyer flask containing 50 ml distilled water and 5-mm diameter solid glass beads. The flask was agitated for several minutes to liberate the spores from the fruiting bodies and to break up the spore clumps. The contents of the flask were then filtered through several layers of sterile Pyrex brand glass wool to remove mycelial fragments. To break up any remaining spore clumps, the resulting spore suspension was agitated with sterile glass beads. This operation was repeated for each test organism used. To obtain the final mixed spore suspension, the individual spore suspensions were combined. A spore count was made using a Fuchs-Rosenthal counting chamber, and the spore concentration was adjusted so that the final spore suspension would contain approximately 100,000 spores per milliliter of each of the five test fungi. Inoculation was accomplished by spraying the tapes in the square bottles with the mixed spore suspension with a DeVilbiss atomizer No. 151 operating at 16 psi air pressure.

After inoculation, the caps were replaced on the bottles and the inoculated specimens incubated for four weeks in a constant-temperature room maintained at 29 ±1 C.

Susceptibility of Pressure-Sensitive Electrical Tapes to a Mixed Spore Suspension

Observations on the extent of mold growth were made at weekly intervals. Table I lists the susceptibility of the tapes to the mixed spore suspension after a 4-week period of incubation. Little growth or no growth was shown by the cellulose acetate cloth tapes, the cellulose acetate film tapes, the cellulose

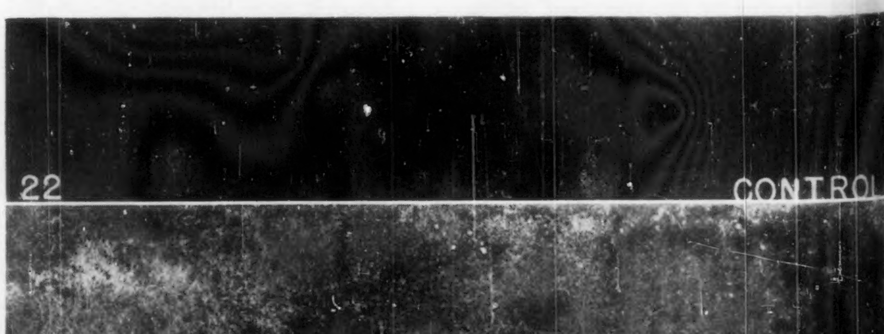
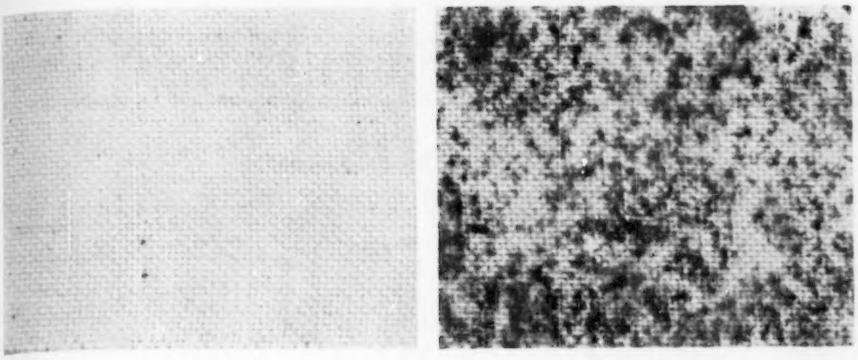


Fig. 2.—Mold Growth on Pigmented Vinyl Film (No. 22) Incubated for 4 Weeks on Mineral Salts Agar.

K_2HPO_4, 0.7 g; KH_2PO_4, 0.7 g; $MgSO_4 \cdot 7H_2O$, 0.7 g; NH_4NO_3, 1.0 g; NaCl, 0.005 g; $FeSO_4 \cdot 7H_2O$, 0.002 g; $ZnSO_4 \cdot H_2O$, 0.002 g; $MnSO_4 \cdot H_2O$, 0.001 g; agar (Difco), 15 g; and distilled H_2O, 1000 ml. pH after sterilization, 6.4.

[4] $MgSO_4 \cdot 7H_2O$, 1.0 g; KH_2PO_4, 2·0 g; KCl, 0.5 g; NH_4NO_3, 3.0 g; $FeSO_4 \cdot 7H_2O$, 0.02 g; dextrose 10 g; agar (Difco), 20 g; distilled H_2O, 1000 ml; 10 ml. 0.1 *N* KOH. pH after sterilization, 5.4.

[5] American Type Culture Collection.



Control Inoculated

Fig. 3.—Mold Growth on Glass Fabric Tape (No. 1) Inoculated with a Mixed Spore Suspension and Incubated on Mineral Salts Agar for 4 Weeks with the Adhesive Side in Contact with the Agar.

acetate butyrate film, some of the vinyl films, and the polyethylene film tapes. In practically all cases, the pigmented tapes were more susceptible than the unpigmented ones (Fig. 2). Incubating the tapes with the backing material in contact with the agar showed as much mold growth in most cases as incubating the tapes with the adhesive material in contact with the agar.

The glass cloth tapes supplied by two manufacturers were extremely variable in susceptibility to the mixed spore suspension. Tape No. 1 had moderate to heavy growth of *C. globosum* and *A niger* (Fig. 3). Tape No. 5 had a trace of growth on the backing and no growth on the adhesive side.

The extent of mold growth listed in Table I is not entirely due to the fungi used as the inoculum since the samples were not sterilized. An attempt was made to sterilize the tapes by autoclaving at 15 psi steam pressure, but all the samples, except the cotton fabric tapes, had their physical properties affected to such an extent that they could not be used.

The crepe paper and flat back paper tapes were very susceptible to mold attack (Fig. 4). In a number of cases the mold growth had deteriorated the paper to such an extent that the tape fell apart on removal from the square bottle. Figure 4 shows the extreme vulnerability of the adhesive material used in yellow crepe paper (tape No. 7). A tape containing polyethylene film laminated to paper was extremely susceptible to fungus attack.

The cloth backing of tapes Nos. 13 and 14 was very susceptible to mold attack with the mixed spore suspension while tape No. 15 had only a trace of mold growth. The adhesive material in tapes Nos. 14 and 15 had no more than a trace of mold growth.

The friction tape was the most susceptible to the fungi. *Chaetomium globosum* appeared frequently as a contaminant on friction tape, and a pure culture of this organism could be obtained by incubating uninoculated strips of the tape.

Effect of Mold Growth on the Breaking Strength of Pressure-Sensitive Electrical Tapes

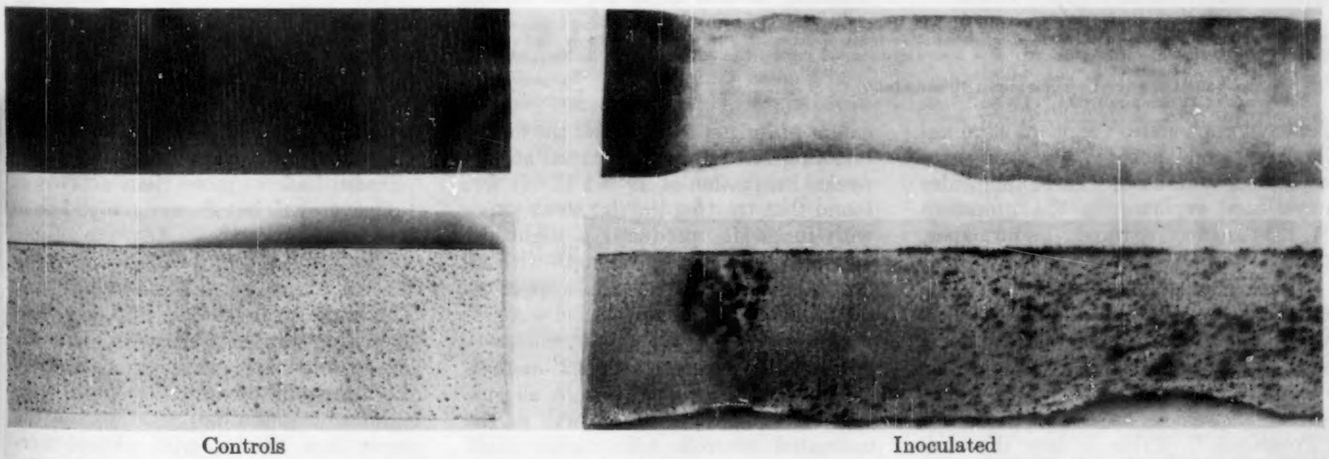
At the end of the four-week incubation period, the specimens of the pressure-sensitive tapes, inoculated as previously described, were removed from the square bottles. The strips of tape were dipped in a 0.1 per cent aqueous solution of mercuric chloride for 2 to 3 min, rinsed in tap water, and dried at room temperature for 24 hr. Breaking strength determinations were made with a Scott Tensile Tester after the tapes were conditioned for 96 hr at 25 ± 1 C. and 50 ± 2 per cent relative humidity. The rate of separation of the jaws of the tester was 20 in. per min, and the initial separation of the jaws was 4 in. The breaking strength of tapes which had deteriorated to a great extent was determined with a Scott Tester Model X5 which has a range of 0.1 lb to 20 lb load.

Table I lists the breaking strengths of the uninoculated controls and the inoculated tapes incubated on mineral salts agar for four weeks. The polyethylene and vinyl film tapes, with one exception for each type of tape, had no significant changes in breaking strength after the exposure. The neoprene had no significant change. The friction, paper, and cloth backed tapes had very high losses in breaking strength, ranging from 37 to 100 per cent. The cloth tapes that were incubated with the cotton sheet backing in contact with the mineral salts agar had much higher losses in breaking strength than the samples incubated with the adhesive material in contact with the agar. A polyethylene film tape laminated to paper also had very high losses in breaking strength.

Resistance to Mold Growth and Effect on the Breaking Strength of Yellow Flat Stock Paper Tape Treated with Four Fungicides

Since paper tapes were found to be very susceptible to deterioration by mold, an attempt was made to fungusproof yellow flat stock paper pressure-sensitive tapes by incorporating suitable fungicides during the manufacturing process.[6] Four fungicides, 2,2′-methylene bis (4-chlorophenol), sodium

[6] Tapes were treated by Minnesota Mining and Manufacturing Co.



Controls Inoculated

Fig. 4.—Heavy Mold Growth on Yellow Crepe Paper Tape (No. 7) Incubated on Mineral Salts Agar for 4 Weeks. Lower Right Sample Was Incubate d with the Paper Backing in Contact with the Agar.

TABLE I.—SUSCEPTIBILITY TO FUNGI AND BREAKING STRENGTH RESULTS OF ELECTRICAL INSULATING TAPES AFTER 4 WEEKS' INCUBATION ON MINERAL SALTS AGAR IN SQUARE BOTTLES AT 29 ± 1 C.

(Samples Were Sprayed with a Mixed Spore Suspension of *Penicillium luteum*, *Chaetomium globosum*, *Aspergillus flavus*, *A. niger*, and *Trichoderma* sp.)

Type of Tape	FA No.	Backing Material	Adhesive Material	Thickness of Tape, mils	Incubation Method[a]	Extent of Fungus Growth[b]	Breaking Strength[c]		Breaking Strength of Controls (not incubated)[d]		Per cent Change
							lb per in.	Standard Deviation, σ	lb per in.	Standard deviation, σ	
Glass cloth	1	Glass cloth	Rubber resin	6.4	A	3	123.3	10.6	143.8	4.8	−14.3
					B	3	136.0	11.4	...	..	−5.4
Glass cloth	5	Fiberglas cloth	Reclaimed rubber	7.8	A	1	130.7	28.5	135.1	19.2	−3.3
					B	0	109.8	19.9	...	..	−18.7
Acetate cloth	19	Celanese acetate cloth	Crude rubber	7.6	A	1–2	40.3	2.5	42.2	2.7	−4.5
					B	1–2	40.8	1.5	...	..	−3.3
Acetate cloth	2	Cellulose acetate	Crude rubber-resin	8.0	A	0–1	34.7	2.1	40.8	2.1	−14.9
					B	0–2	37.0	3.5	...	..	−9.3
Acetate cloth	3	Celanese rayon cloth	Crude rubber	8.3	A	1	38.3	2.7	40.9	0.9	−6.3
					B	0–1	38.5	1.1	...	..	−5.9
Acetate film cloth	4	Cellulose acetate film laminated to cellulose acetate cloth	Rubber resin	8.0	A	0	40.8	1.6	44.9	0.2	−9.1
					B	0	40.0	1.7	...	..	−10.9
Cellulose acetate film	10	Cellulose acetate film	Synthetic	3.9	A	0–1	24.3	0.5	21.5	0.5	+13.0
					B	0	23.8	0.4	...	..	+10.7
Cellulose acetate film	11	Cellulose acetate film	Rubber resin	3.0	A	0–1	23.2	1.2	21.2	0.6	+9.4
					B	0–1	23.7	1.0	...	..	+11.8
Acetate film	12	Cellulose acetate butyrate film	Transparent pressure sensitive	3.9	A	0	15.3	0.5	13.3	0.5	+15.0
					B	0	15.0	0	...	..	+12.8
Vinyl plastic film	20	Vinyl film	Buna rubber resin	7.0	A	0	31.3	0.5	30.2	0.8	+3.6
					B	0	30.8	1.5	...	..	+2.0
Vinyl plastic film	21	Pigmented vinyl film	Buna rubber resin	12.5	A	0–1	40.5	1.0	40.2	1.4	+0.7
					B	0	41.2	1.5	...	..	+2.5
Vinyl plastic film	22	Pigmented vinyl film	Buna rubber resin	10.0	A	3–4	22.0	0	20.8	1.5	+5.8
					B	1	21.6	1.2	...	..	+3.8
Vinyl plastic film	24	Pigmented vinyl film	Buna rubber resin	..	A	1–2	32.6	1.3	31.7	2.9	+2.8
					B	1–2	30.0	2.9	...	..	−5.4
Polyethylene film	17	Oriented pigmented (white) polyethylene film	Synthetic	6.0	A	0–1	11.4	0.4	11.3	0.4	+0.9
					B	0	10.8	0.4	...	...	−4.4
Polyethylene film	18	Oriented pigmented (black) polyethylene film	Synthetic	8.4	A	0–2	22.1	0.8	20.3	1.4	+8.9
					B	0	21.7	0.9	...	..	+6.9
Polyethylene film	23	Oriented pigmented (red) polyethylene film	Synthetic	7.8	A	1–2	13.2	0.3	14.0	0.9	−5.7
					B	0–1	13.1	0.2	...	..	−6.4
Neoprene	25	Vulcanized Neoprene	Buna rubber	22.6	A	1–2	14.4	0.9	14.2	2.2	+1.4
					B	0–1	14.5	1.0	...	..	+2.1
Yellow crepe	6	Rope stick paper impregnated with rubber resin, back-sized with shellac	Rubber resin	11.0	A	0–2	10.2	0.3	25.0	0.1	−59.2
					B	4	0.2	0.2	...	..	−99.2
Crepe paper	7	Kraft paper impregnated with an alkyd resin	Crude and synthetic rubber	8.5	A	4	1.0	0.0	25.0	0.8	−96.0
					B	4	1.1	0.2	...	..	−95.6
Flat paper	8	Rope stick paper impregnated with rubber resin, back-sized with shellac	Rubber resin	5.4	A	3–4	4.5	6.8	55.1	0.2	−91.8
					B	4	Samples tore		...	..	−100.0
Flat paper	9	Fiber paper impregnated with an alkyd resin	Crude and synthetic rubber	6.8	A	4	1.3	0.8	61.7	2.9	−97.8
					B	4	0.8	0.3	...	..	−98.7
Polyethylene film laminated to paper	16	Polyethylene film laminated to troya tissue	Vistanex resin	6.0	A	2–3	5.2	0.4	38.3	0.6	−86.4
					B	4	5.6	0.5	...	..	−85.4
Friction tape (Grade A)	13	Cotton sheeting	Friction rubber compound	14.5	A	4	1.8[e]	2.4	67.4	3.7	−98.8
Cloth fabric	14	Cotton sheeting washed to remove electrolytes	Reclaimed and synthetic rubber	14.0	A	4	28.7	2.9	54.8	0.6	−47.6
					B	0–1	2.7	1.2	...	..	−95.1
Cloth fabric	15	Cotton sheeting coated with an oil-modified phenol-formaldehyde resin	Reclaimed and synthetic rubber	13.9	A	1	29.8	4.2	47.6	1.8	−37.4
					B	0–1	2.2	0.5	...	..	−95.4

[a] A = Adhesive side of tape was incubated in contact with the agar. B = The backing side of tape was incubated in contact with the agar.
[b] Code for fungus growth: 0 = no growth; 1 = trace of growth; 2 = slight growth or up to 20 per cent of surface moldy; 3 = moderate growth, 20 per cent to 50 per cent of surface moldy; 4 = heavy growth, 50 per cent to entire surface moldy.
[c] Values are averages of 6 samples.
[d] Control values are averages of at least 10 samples.
[e] Average of 11 samples.

pentachlorophenate, copper 8-quinolinolate, and phenyl mercuric saccharinate, were used. These fungicides have been reported in the literature (1, 2, 3) as effective fungicides for paper, textiles, and electrical components.

In order to determine the fungus resistance of the treated tapes, 6-in. strips were placed on nonnutrient mineral salts agar in French square bottles and inoculated by spraying with a mixed spore suspension as described under "Procedure." Table II lists the concentration of the fungicides in the tapes as determined by chemical analysis, the extent of fungus growth, and the loss in breaking strength of the tapes after 4 weeks' incubation at 29 ±1 C. It was found that treating the flat stock paper with fungicides produced a slight decrease in the breaking strength with all the fungicides, except the copper 8-quinolinolate where an increase was produced.

The tapes treated with 2,2′-methylene bis (4-chlorophenol) were as susceptible to heavy mold growth as the untreated controls. No visible mold growth was present on the samples treated with copper 8-quinolinolate and phenyl mercuric saccharinate. The tape treated with sodium pentachlorophenate had no more than a trace of fungus growth but showed a high loss in breaking strength. All the tapes showed losses in breaking strength ranging from 3 per cent to 99 per cent. The tape treated with 0.84 per cent phenyl mercuric saccharinate had the lowest loss in breaking strength. All the losses in breaking strength were significant at the 0.01 level, except the paper tape treated with phenyl mercuric saccharinate and incubated with the backing material in contact with the agar.

TABLE II.—RESISTANCE TO MOLD GROWTH AND EFFECT ON THE BREAKING STRENGTH OF YELLOW FLAT STOCK PAPER. ELECTRICAL INSULATING TAPE TREATED WITH FOUR FUNGICIDES.

(Samples Were Sprayed with a Mixed Spore Suspension and Incubated on Mineral Salts Agar for 4 Weeks at 29 ± 1 C.)

Fungicide	Concentration of Fungicide, per cent	Incubation Method[a]	Extent of Fungus Growth[b]	Breaking Strength,[c] lb per in.	Standard Deviation, σ	Per cent Loss Over Unincubated Specimens	Breaking Strength, Unincubated Controls,[d] lb per in.	Standard Deviation, σ
Untreated controls (FA 26)	..	A	2	5.3	5.0	91.0	58.9	1.2
		B	3	1.2	0.6	98.0		
2,2'-Methylene bis (4-chlorophenol)	0.57	A	2	5.8	2.3	89.9	57.5	0.8
		B	4	0.5	0	99.1		
Sodium pentachlorophenate	0.50	A	0	44.8	6.1	18.2	54.8	0.6
		B	0–1	7.4	6.0	86.5		
Copper 8-quinolinolate	0.89	A	0	49.7	6.0	25.2	66.4	1.4
		B	0	47.8	7.0	28.0		
Phenyl mercuric saccharinate	0.84	A	0	54.8	1.3	2.7	56.3	2.1
		B	0	48.3	1.1	14.2		

[a] A = Adhesive side of tape was incubated in contact with the agar. B = The backing side of tape was incubated in contact with the agar.
[b] Code for fungus growth: 0 = no growth; 1 = trace of growth; 2 = slight growth or up to 20 per cent of surface moldy; 3 = moderate growth, 20 to 50 per cent of surface moldy; 4 = heavy growth, 50 per cent to entire surface moldy.
[c] Values are averages of 5 to 6 samples.
[d] Average of 10 samples.

Discussion of Results

Pure thermoplastic synthetic resins, such as cellulose acetate butyrate polyethylene, polyvinyl chloride, and polyvinyl chloride - acetate, have been reported by a number of laboratories (11) as resistant to mold growth. Fungus-resistance tests conducted at this laboratory have shown that polyethylene film is not subject to attack by five species of fungi. Brown (4, 11) reported that the National Bureau of Standards and the British Ministry of Supply found polyethylene mold inert. Cellulose acetate has been reported as very slightly susceptible to mold by the National Bureau of Standards and not susceptible by two other laboratories (11). However, with few exceptions, the electrical insulating tapes investigated are not fabricated entirely from the pure resins but contain plasticizers, coloring matter, lubricants, and other materials which are mold susceptible. Examina- of Table I shows that in almost all cases the colored tapes (especially the black) had more mold than the uncolored ones.

The small amount of mold growth visible on some of the plastic tapes may be attributed to the growth of germinated spores on the dust particles or on the ungerminated spores present on the tape samples. The spore charge used as inoculum in these tests was very high. Only a small portion of the spores in the inoculum germinate even under favorable conditions. Therefore, any spores that remain ungerminated or which are present as detritus serve as a food source for the spores that are first to germinate.

The problem of the effect of the incubation method (that is, the environmental conditions to which the sample is exposed), in the absence of mold growth on the physical properties (in this case, the breaking strength) of the tape samples, has been of some concern to many investigating the deterioration of materials by molds. To eliminate the growth of fungi and study the effects of moisture, the culture media or the incubation methods, a number of sterilization methods have been used. The samples may be sterilized by steam under pressure, by ultraviolet radiation, or by chemicals. Although these methods are effective in some cases, most of them do have a deleterious effect on the physical properties of the materials. The chemicals that have been used for sterilization or inhibiting the growth of fungi are volatile fungicides (10) and inert and toxic gases, such as helium, argon, nitrogen, carbon monoxide, and illuminating gas. This laboratory has investigated the use of helium gas and about 31 volatile fungicides. Of these, propylene oxide and a mixture of paraformaldehyde and *p*-dichlorobenzene (3:1) have given fair results. Some of the tests indicated that the volatile fungicides may have affected the physical properties of the tapes. More investigative work is desirable on suitable methods of determining the effect of the incubation method, in the absence of fungus growth, on the physical properties of the tapes.

Conclusions

1. Plastic tapes, such as cellulose acetate film and cloth, cellulose acetate butyrate, vinyl, polyethylene, and Neoprene had no more than slight mold growth and no more than slight changes in breaking strength. Glass fabric tapes were susceptible to mold growth but showed no appreciable loss in breaking strength.

2. Paper, cloth, and friction tapes were deteriorated by mold and showed large losses in breaking strength.

3. Flat stock paper tape treated with phenyl mercuric saccharinate (0.84 per cent) offered some protection against mold attack and had the least loss in breaking strength of treated paper tapes.

Acknowledgment:

The cooperation of the following tape manufacturers is acknowledged: Minnesota Mining and Manufacturing Co., Industrial Tape Corp., and Bauer and Black. Appreciation is due to C. C. Fawcett, E. R. Rechel, and M. Frager of the Pitman-Dunn Laboratory and to the Ordnance Department for permission to publish this paper.

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Roundness Testing of Glass Spheres

By Armand E. Keeley[1]

With the greatly increased use of reflectorized highway traffic striping and the glass bead reflectorization of traffic signs has come the need of detailed specifications for the minute glass spheres to establish the physical characteristics affecting their life and degree of reflectance.

Until recently, a very crude description sufficed, such as, "The glass spheres shall be uniformly graded, free from bubbles and milkiness or opaque particles, and not more than 30 per cent shall be irregular particles, fused spheroids, etc." The manner of determining such characteristics as roundness, opaqueness, physical and chemical stability was not specified. No tests were available and visual examination alone sufficed in most cases to determine acceptance or rejection. Hundreds of thousands of gallons of reflectorized striping materials were purchased on brand name, from proved sources, under such crude specifications.

With increased use of reflectorizing materials and a corresponding increase in sources of production has come the need for tighter and more intelligent specifications, capable of accurate and fair enforcement. Coupled with this need has been the slowly growing realization of using agencies that not all types and kinds of so-called glass spheres are satisfactory; nor are all traffic paints satisfactory glass sphere binders; that such characteristics as per cent of rounds, clarity of glass and physical and chemical stability in service are vital factors in determining the difference between good and poor spheres, just as similar fundamental characteristics in binders make the difference between durable and short-lived lines; and durability and continued reflective services are both vital and necessary in order to justify the higher costs of glass-bead paint combinations.

Increased interest in these phases of material tests led to a request to ASTM by several State Highway Departments in 1949, for the promulgation of tests, with respect to both apparatus and procedures, which could be used in the purchase of such materials. These requests were referred to the "Night Visibility" group 3, of Subcommittee IV on Traffic Paints of ASTM Committee D-1 on Paint, Varnish, Lacquer, and Related Products, where they were the subjects of spirited discussion and debate in meetings at Atlantic City, in June, 1949.

As a result of this discussion, the author was appointed to head up a task force group, in group 3, to undertake the necessary research and experiment required to develop test procedures and apparatus to determine per cent of rounds, physical stability, chemical stability, reflectance characteristics, and index of refraction on glass spheres used for highway marking purposes. Many members of group 3 volunteered to assist, but, necessarily, the early stages had to be more or less a one-man project, cooperation being later required to prove out suggested tests.

At the June, 1950, meeting in Atlantic City final reports were made on recommended procedures and apparatus for testing roundness and physical stability, and these will shortly be voted on by letter ballot in Subcommittee IV. In addition, progress reports were made on other phases, such as clarity, reflectance, and chemical stability.

This article deals with the first and, by far, the most intriguing problem, namely, an accurate and reproducible mechanical means of determining the percentage of true spheres.

The first several months were devoted to suggesting, trying, and discarding every conceivable idea and principle. Crude ways of testing were many, but all had either too much of a personal element which would affect the results, or too great a mechanical loss or error. Production machinery, designed to separate rounds from slugs in plant production, was eminently satisfactory for the purpose, but later proved to be incapable of reduction to laboratory size with high reproducibility and accuracy.

A good manual test was easily developed by pouring glass spheres over a sloping panel, tapping with a rod, and after the rounds had rolled free and had been collected, weighing them after visual examination under magnification had indicated satisfactory separation. This plainly had too much of the personal element in it to be satisfactory and the personal judgment of a technician making a test in production plant "A" was in no way related to the judgment of another technician making a test in highway laboratory "X," but it did point a way to a solution of the problem.

In searching for a source of controllable vibrations, we were led to try electrical vibration feeders of a type used for many years in industry in accurately feeding granular materials. In this type

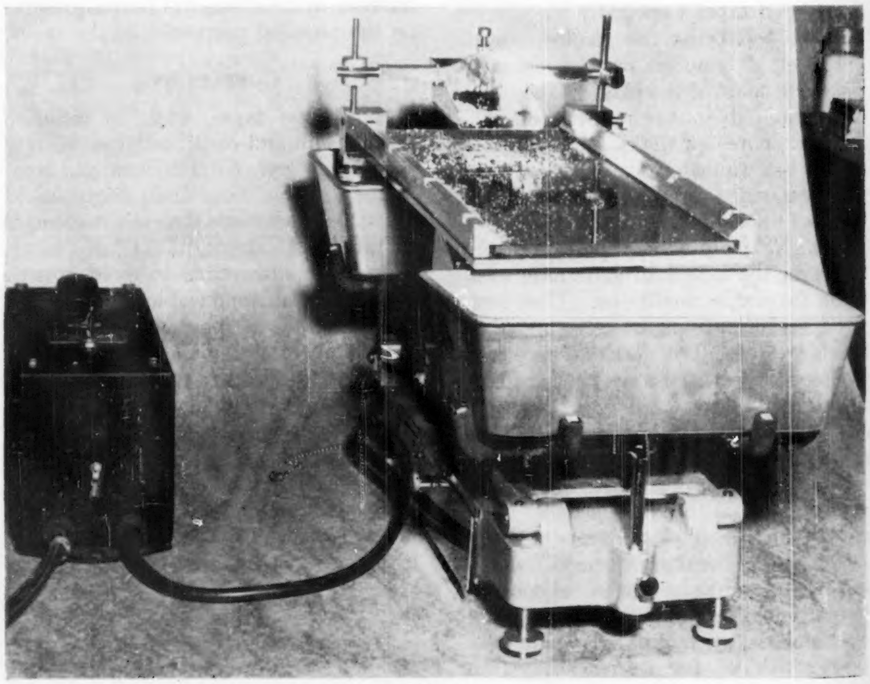

Fig. 1.

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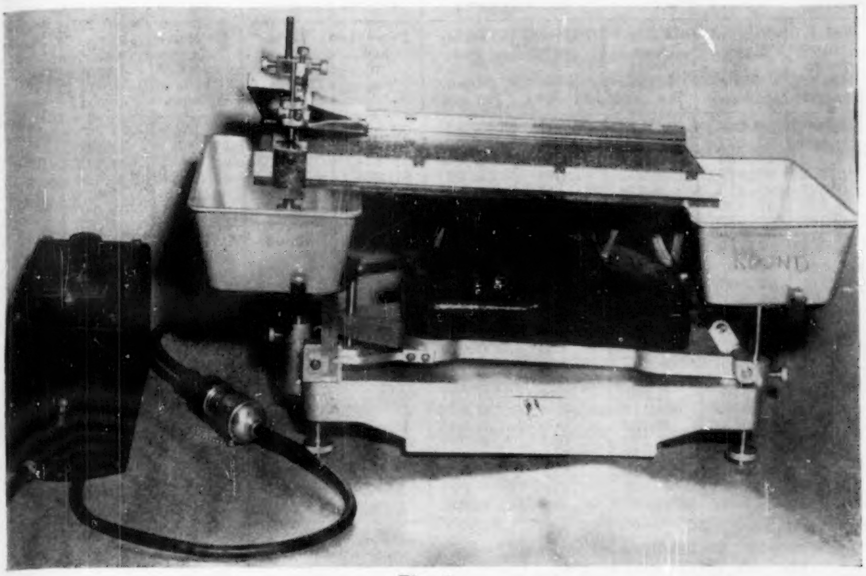

Fig. 2.

of device, the material in the feed trough falls back perpendicularly, when the trough is pulled sharply backward out from under it, to a new position forward in the trough pan and then, as springs return it up and forward, the material is carried with it. This action is repeated sixty times per second. A first pilot machine was built and after many months of tests and changes the final roundness tester, capable of accurate and reproducible tests, was an accomplished fact.

Primarily, it consists of a smooth plate-glass panel suitably mounted upon an electric vibrator feeder unit, the whole mounted upon a hinged base in such a manner that the angle of slope of the vibrating glass plate with the horizontal may be varied at will and fixed in any predetermined position (Figs. 1 and 2).

Glass spheres to be tested are dropped from a feeder pan onto the surface of the vibrating panel, with an adjustable gate controlling rate of feed.

Exhaustive tests over many months developed an angle of slope for each size glass sphere that would permit true spheres to roll *down* the slope, against the throw of the vibrator, into a collecting pan at the lower end, while slugs or irregular particles either march uphill against the slope, or remain stationary on the panel. Because of the difference in the movement of the vibrator at opposite ends of the glass panel, the greater amount of throw is on the upper one third of the panel, on the "feed" end of the vibrator. For this reason, the feed pan is so located to deposit the glass to be tested on the upper third of the panel. They are permitted to drop a distance of about ½ in. from the feeder pan to the glass panel in order to take advantage of a primary separation caused by bouncing. Despite this, however, some irregular particles will be carried part way down the panel by the pushing effect of the true spheres rolling downhill and will remain there, beyond the power of the vibrator to move them uphill, and some small number will eventually fall into the collecting pan for true spheres.

Similarly, the upward march of a large group of irregular particles near the upper end of the panel will trap some true spheres and cause them to be deposited in the irregular collecting pan. For these reasons perfect separation could not be made in one operation, but it soon developed that these misplaced particles could be properly collected by successive rerunning of slugs and true spheres on the vibrator. The smaller the spheres, the greater the number of reruns necessary to effect satisfactory separation. While original development was based on the theory of a different slope for each diameter sphere, it soon developed that certain ranges in sizes could be permitted at one slope setting without adversely affecting the accuracy of results.

From these tests, a calibration curve and chart was finally developed, as shown in Fig. 3. This chart indicates the permissible size groupings, the slope setting for each group, or, in the case of spheres of uniform size, the slope setting for that diameter sphere, and the number of reruns of slugs and true spheres required after primary separation.

The operation of the roundness tester is simple. The feed trough is filled with the glass to be separated, the feed gate set to allow a monolayer of particles to pass through. The feeder may either be set on one side, or spanning the panel, at about the upper one-third point. The

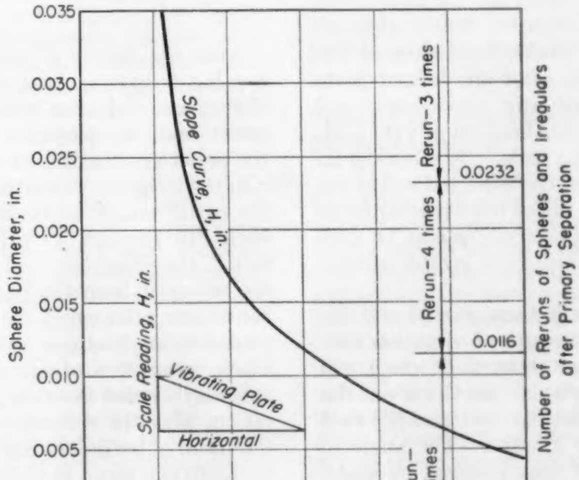

Fig. 3.—Calibration Chart Rounding Tester.

INDICATING SLOPE SETTINGS, SCREEN GROUPS AND RERUNS REQUIRED. SIZE GROUPS AND SCREENINGS FOR GRADUATED SPHERE MIXES.

	Sphere Diameter, in.
Retained on No. 30 sieve	0.0232
Passing No. 30, retained on No. 40 sieve	0.0164
Passing No. 40, retained on No. 50 sieve	0.0116
Passing No. 50, retained on No. 70 sieve	0.0084

TABLE I.—REPRODUCIBILITY TEST RUNS, ROUNDNESS TESTER.

	No. 4 Spheres		No. 6 Spheres		No. 7 Spheres		No. 9 Spheres		No. 11 Spheres		No. 12 Spheres		Average for Total 150 Runs
	Percentage of True Spheres	Variation from Mean, Per cent	Percentage of True Spheres	Variation from Mean, Per cent	Percentage of True Spheres	Variation from Mean, Per cent	Percentage of True Spheres	Variation from Mean, Per cent	Percentage of True Spheres	Variation from Mean, Per cent	Percentage of True Spheres	Variation from Mean, Per cent	
No. 1	69.305	+0.759	83.313	+0.581	97.368	−0.161	97.145	+0.039	92.324	−0.063	98.165	+0.075	
No. 2	69.362	0.816	83.041	0.309	97.377	0.152	97.102	−0.004	92.224	0.163	98.155	0.065	
No. 3	69.352	0.806	83.035	0.303	97.355	0.174	97.062	0.046	91.454	0.933	98.107	0.017	
No. 4	68.973	0.427	83.254	0.522	97.317	0.212	97.075	0.031	91.803	0.584	98.234	0.144	
No. 5	69.044	0.498	83.259	0.527	97.415	0.114	97.114	+0.008	92.131	0.256	98.027	−0.063	
No. 6	68.925	0.379	83.382	0.650	97.430	0.099	97.081	−0.025	92.305	0.082	98.130	+0.040	
No. 7	68.870	0.324	83.008	0.276	97.417	0.112	97.073	0.033	92.435	+0.048	98.160	0.070	
No. 8	68.526	−0.020	83.065	0.333	97.427	0.102	97.113	+0.007	92.434	+0.047	98.160	0.070	
No. 9	68.355	0.191	83.065	0.333	97.430	0.099	97.137	0.031	92.387		98.161	0.071	
No. 10	68.068	0.478	83.006	0.274	97.467	0.062	97.124	0.018	92.411	0.024	98.163	0.073	
No. 11	68.251	0.295	82.951	0.219	97.500	0.029	97.213	0.107	92.414	0.027	98.141	0.051	
No. 11	68.334	0.212	83.041	0.309	97.527	0.002	97.206	0.100	92.457	0.070	98.037	−0.053	
No. 13	68.168	0.378	82.910	0.188	97.554	+0.025	97.207	0.101	92.354	−0.033	98.075	0.015	
No. 14	68.250	0.296	82.818	0.086	97.553	0.024	97.158	0.052	92.387		98.055	0.035	
No. 15	68.187	0.359	82.490	−0.242	97.567	0.038	97.128	0.022	92.462	+0.075	98.036	0.054	
No. 16	68.254	0.292	82.480	0.252	97.586	0.057	96.918	−0.188	92.519	0.132	98.061	0.029	
No. 17	68.304	0.242	82.463	0.269	97.619	0.090	97.020	0.086	92.563	0.176	98.074	0.016	
No. 18	68.303	0.243	82.255	0.477	97.615	0.086	97.039	0.067	92.579	0.192	98.038	0.052	
No. 19	68.323	0.223	82.072	0.660	97.644	0.115	97.014	0.092	92.573	0.186	98.060	0.030	
No. 20	68.191	0.355	82.072	0.660	97.655	0.126	97.060	0.046	92.583	0.196	98.055	0.035	
No. 21	68.491	0.055	82.112	0.620	97.654	0.125	97.055	0.051	92.565	0.178	97.987	0.103	
No. 22	68.291	0.255	82.017	0.715	97.684	0.155	97.095	0.011	92.583	0.196	97.982	0.108	
No. 23	68.532	0.014	81.961	0.771	97.649	0.120	97.163	+0.057	92.591	0.204	98.003	0.087	
No. 24	68.566	+0.020	81.983	0.749	97.712	0.183	97.179	0.073	92.566	0.179	98.094	+0.004	
No. 25	68.430	−0.116	82.263	0.469	97.715	0.186	97.184	0.078	92.581	0.194	98.100	0.010	
Mean, per cent	68.546		82.732		97.529		97.106		92.387		98.090		
Average variation from mean, per cent	0.320[a]		0.432[a]		0.106		0.055		0.169		0.054		0.189
Max. plus variation, per cent	0.816		0.650		0.186		0.107		0.204		0.144		0.351
Max. minus variation, per cent	0.478		0.771		0.212		0.188		0.933		0.108		0.448
Max. variation range, per cent	1.294		1.421		0.398		0.295		1.137		0.252		0.799
Weight at start of test, g	49.9766		49.9551		49.9790		49.9728		49.9928		49.9882		
Weight at end of test, g	49.6667		49.4424		49.8211		48.9600		49.9327		49.9126		
Loss in weight, g	0.3099		0.5127		0.1579		1.0128		0.0601		0.0756		
per cent	0.62		1.02		0.31		2.02		0.100		0.15		0.703
Diameter range, in.	0.033 to 0.036		0.0195 to 0.032		0.0165 to 0.0195		0.0140 to 0.0195		0.0058 to 0.0097		0.0041 to 0.0097		

[a] In regard to the loss of rounds on the No. 4 and 6 spheres, this is the result of our starting out these reproducibility tests with an untrained operator in order to determine whether someone without any previous background could do accurate work. We started with the larger spheres, and it was some time after the start before the operator could gage the height from which these spheres should be dropped in order to have them bounce on the plate but not bounce so wildly that some of them jumped off the plate and became totally lost. In the larger spheres, we found that this distance was very critical, and on the first part of the runs on both No. 4 and 6, the true spheres which bounce rather high, bounced completely off the vibrating table and were lost, and consequently, the condition indicated by the table of reruns existed. After having some experience, however, and when getting into the smaller size spheres, the operator learned to gage the dropping distance with a much greater accuracy, with the result that we did not have any perceptible change in the percentage of rounds as compared with slugs in each group.

glass plate is leveled by means of the leveling screws, after the hinged plate bearing the vibrator mechanism and the glass plate has been set at "O" position on the slope scale. By means of an adjusting screw, the left-hand end of the hinged plate is raised until pointer reads the "H" height on scale, as may be indicated for that size glass on the calibration chart.

The vibrator is then started and the amplitude or strength of vibration controlled by rheostat to that which will permit the irregular particles on the upper 3 in. of plate to move steadily (not bounce wildly) upward. The angle of the feed pan is then changed by slight finger pressure to permit the glass to move slowly and evenly from the feeder onto the plate. This "slowly and evenly" is most important, for if the feed is too fast, spheres will bunch up or flood on the glass panel below the feed pan, thereby preventing good separation and causing a large number of true spheres to be trapped by the irregular particles and carried into the irregular pan.

After the supply of glass in the feed pan has been exhausted, the vibrator is shut down, and after true spheres have rolled free, the particles remaining on the panel are brushed or scraped uphill into the irregular collecting pan. When the entire sample to be tested has thus been run through a "primary separation," the irregulars and true spheres are removed from the pans to suitable containers, after which the irregulars are placed in the feed pan and reseparated. Upon completion of this step, the true spheres collected from the primary separation, plus the spheres collected from the rerun of irregulars, are placed in the feed pan and rerun in the same manner. This constitutes one rerun and this is continued the number of times indicated for that sizing, or size group of spheres, from the calibration chart. Upon completion of the required number of reruns, the collected true spheres are weighed and the collected irregulars are weighed and percentages computed on the total collective weight, thereby eliminating from consideration those particles which may be lost in handling.

Reproducibility tests were run on six different size groupings of glass spheres. Each sample was separated twenty-five times and the results recorded. After each of the twenty-five runs, the irregular and true spheres were placed in one container and suitably remixed mechanically before starting the next run. The results of these reproducibility runs are indicated in Table I and indicate a very small percentage of error, probably only a small part of the error which might result in the method of collecting the glass sample to be tested from the original shipping container.

Acknowledgment:

In closing, the author would like to acknowledge his indebtedness for the assistance rendered him by many members of the subgroup, particularly Victor Lyon, Director, Missouri State Highway Testing Laboratory, and A. B. Cornthwaite of the Virginia State Highway Dept. Testing Laboratory.

Calendar of Other Society Events

"Long" and "short" calendars will appear in alternate BULLETINS. *The "short" calendar notes meetings in the few immediate weeks ahead—the "long" calendar for months ahead.*

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS—May 13–16, Hotel Muehlenbach, Kansas City, Mo.

SOCIETY EXPERIMENTAL STRESS ANALYSIS—May 16–18, Washington, D. C.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Great Lakes District, May 17–19, Madison, Wis.

AMERICAN IRON & STEEL INSTITUTE—May 23—24, New York, N. Y.

AMERICAN SOCIETY FOR QUALITY CONTROL—Annual Convention, May 23–24, Hotel Cleveland, Cleveland, Ohio.

SOCIETY OF THE PLASTICS INDUSTRY—Annual National Meeting, May 24–25, Greenbrier Hotel, White Sulphur Springs, West Va.

SOCIETY OF APPLIED SPECTROSCOPY—Annual Meeting, May 25–26, Socony-Vacuum Training Center, New York, N. Y.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS—38th Spring Meeting, May 27–30, Hotel Statler, Detroit, Mich.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Semiannual Meeting, June 11–15, Hotel York, Toronto, Canada.

NATIONAL APPLIED MECHANICS CONGRESS—June 11–16, Chicago, Ill.

AMERICAN SOCIETY OF CIVIL ENGINEERS—June 13–16, Louisville, Ky.

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS—Annual Meeting, June 14–16, Minneapolis, Minn.

American Society for Testing Materials—Annual Meeting, June 18–22, Atlantic City, N. J.

MALLEABLE FOUNDERS' SOCIETY—Annual Meeting, June 21–22, The Homestead, Hot Springs, Va.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION—Annual Meeting, June 25–29, Michigan State College, East Lansing, Mich.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Summer General Meeting, June 25–29, Royal York Hotel, Toronto, Canada.

INSTITUTE OF AERONAUTICAL SCIENCES—Annual Summer Meeting, June 27–28, I.A.S. Western Headquarters, Los Angeles, Calif.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS—Semi-Annual Meeting, July 2–4, Portland, Oregon.

AMERICAN ELECTROPLATERS' SOCIETY—July 30–August 2, Statler Hotel, Buffalo, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Pacific General Meeting, August 20–23, Portland, Oregon.

ILLUMINATING ENGINEERING SOCIETY—August 27–30, Hotel Shoreham, Washington, D. C.

Johnson and Auth's Fuels and Combustion Handbook

THIS NEW handbook, edited by A. J. Johnson and G. H. Auth, provides a comprehensive treatment of the properties, characteristics, and uses of all solid, liquid, and gaseous fuels. The basic types of combustion and of the several fuels are discussed in detail, as well as all pertinent combustion equipment. Such corollary factors as heat balances, smoke prevention, and draft requirements are given ample and novel treatment. The individual chapters are, in effect, digests of specific topics which combine to cover the entire field of combustion engineering. Numerous references to ASTM Specifications and Symposiums are made throughout the handbook.

The presentation requires a minimum of effort for using the material. Wide application is made of the rapid computation technique of alignment charts. Wherever possible, formulas have been replaced or at least supplemented by tables and graphs. Tables are included to show comparative advantages, disadvantages, salient features, applications, average performance data, and general characteristics of optional equipment. Line drawings or diagrammatic sketches are used in almost all cases rather than the less easily understood photographs or commercial art drawings.

The Handbook is compiled from approximately 450 major references, with the permission and cooperation of their authors. Of these references, less than 50 are older than 1937; over half were originally published in 1946–1949. Thus, many new advances are covered, such as the latest information on synthetic fuels; the heat pump; gas turbines; spreader stokers; latest research in combustion; present-day furnace and equipment design; package boilers; etc.

The Handbook, which comprises 915 pages, is published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 18, N. Y., and sells for $12.50.

Properties of Lubricating Oils and Engine Deposits

AS THE title indicates the book by C. A. Bowman covers two broad topics, (*a*) properties of new and used engine lubricants, and (*b*) engine deposits and their relationship to operating conditions, fuels, and lubricating oils.

Regarding the first topic the simple properties of lubricants are discussed with emphasis on viscosity-temperature and viscosity-pressure relationships. Data are given on the effect of viscosity and volatility on oil consumption with the conclusion that the former is the more important variable. A chapter on contamination of lubricating oil describes a method for determining soot, lacquer, asphaltenes, and ash of used oils; and presents considerable data showing how these components increase with hours of operation in both diesel and gasoline engines.

The section on engine deposits is concerned with the effect of operating conditions, hours of operation, engine load, fuel and lubricant on carbon, sludge, and lacquer deposits in engines. A chapter is devoted to cylinder wear as influenced by engine load and number of engine starts and another brief one on general engine maintenance practices. Tables are given in the appendix enabling one to calculate viscosity-index and to convert centistokes to Saybolt, Redwood, and Engler units.

The book is small, therefore with the exception of the specific phases mentioned above, does not give as much information as one would like to have on such a complex subject. With respect to fuels and lubricants it is far behind American experience since there is little or no information on high sulfur diesel fuels nor on the beneficial effects of additives in the lubricating oil.

The book is published by MacMillan and Co., Ltd., St. Martin's Street, London. It contains 170 pages and sells for 15/.

J. C. GENIESSE

Legal Aspects of Standards and Sampling

AT TWO recent meetings Prof. Frank R. Kennedy, College of Law, State University of Iowa, has presented interesting papers dealing with legal aspects of sampling and standards. The first paper on sampling was presented at the Fourth Midwest Quality Control Conference, St. Louis, Mo., November 10, 1949. The one on standard of quality was presented at the 110th Annual Meeting of the American Statistical Association, Chicago, Ill., December 28, 1950.

Many ASTM members are either interested or concerned with legal discussions of this kind and they may wish to note that Professor Kennedy's paper—Some Legal Aspects of Sampling—is published in the January and March, 1951, issues of *Industrial Quality Control* published by American Society for Quality Control. The Executive Secretary is Simon Collier, Johns-Manville Corp., New York City. Headquarters: 22 East 40th St., New York City.

A very pertinent paper on legal aspects of standardization by James V. Hayes (Standardization and the Anti-trust Laws) appeared in the August, 1946, ASTM BULLETIN. Professor Kennedy makes frequent references to that paper in his discussion dealing with a Standard of Quality.

Papers from International Bridge Building Congress

PUBLISHED by the General Secretariat in Zurich, the "1949 Publications of the International Association for Bridge and Structural Engineering" contains (in three languages) papers by authoritative authors on the general subject of bridge engineering. Just to mention a few, there are papers on the deflection theory of suspension bridges, testing of highway bridges, bridge deck systems, impact and fatigue problems in cast iron girder bridges and calculating the flexible pylons of suspension bridges. All of the present volume, containing 25 papers of which thirteen are in English, nine in French, and three in German, are contributions which were submitted to the Sixth Working Meeting of the Third Congress of the I.A.B.S.E. at Liége. For the papers written in languages other than English, the titles and summaries are given in English. Further information can be obtained by writing to F. Stüssi, Professor at the Swiss Federal Institute of Technology in Zurich.

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On this page are announcements by leading organizations and individuals of their services.

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